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Philosophy of Science

VOL. 3 January, 1936 NO. 1

A Metaphysics of Design without Purpose[1]

BY

MERRITT HADDEN MOORE

THE problem of this paper may be stated simply. It is that, in dealing with the nature of reality, it is not only possible, but more fruitful and more accurate, to deal with the category of order or design, meaning by this, the structure or relationship of the parts of a whole, without associating this idea with that of purpose or teleology, than it is to conjoin these concepts. It is the purpose of the paper to show why this separation is advisable, and to indicate the background of the problem which tends to make difficult the separation of these two concepts.

I

So far as records show, men have had their greatest success in getting hold of what appears to be the nature of the multifarious and variegated phenomena of the universe by imputing to them ordered relationships similar to those through which human ends are achieved. At first this took the form of crude and overt anthropomorphic statement. The difficulties of this position early became apparent, however, and the more progressive, persistent,

[1] This article is as read before the meeting of the Eastern Division at the American Philosophical Association in New York, December 27, 1934, with the exception of some slight changes of terminology.

and consistent thinkers began to work away from the primitive form of the doctrine. As everyone familiar with the history of thought knows, this has tended to go on, until we have been led to resort to a set, or to sets of depersonalized metaphysical principles as the basis for our statements about the nature of things.

However, one element of the earlier attitude still remains. This is the element of design. This idea is both a natural, and a necessary basis for knowledge. But, in many cases, at least, it is still linked with the idea of teleology, although the latter is no longer anthropomorphically conceived. The basic metaphysical assumption involved in this case is that however impersonal the forces of nature may be, and however natural their manifestations, they are actually working toward ends which are set up, and are finally to be attained, by a being, a force, an essence, or what not, which controls their overt expression. It has long been the opinion of many thinkers that this principle is inseparable from that of order or structure. This is the opinion which I wish to challenge.

No one interested either in the problem of gaining control over nature, or in that of understanding it, can deny that in some sense or other reality is ordered and related in such ways that reason can deal with it. If desired, this fact may be made the basis of a statement that nature is rational. But care must be exercised in pointing out just what one means by this phrase. It may, and, I think, should, refer simply to the fact that has just been indicated—that reality and reason are commensurable, and that it can be significantly said that the latter knows the former. As a matter of fact, the statement in question has more often meant that nature is under the guidance of a rational being or a principle whose processes and purposes we follow as we gain greater understanding of the processes of nature. Once the *fact* of knowledge is admitted, the first alternative is not subject to the slightest doubt; on the other hand, the latter seems to be both unnecessary and confusing.

With the exception of avowed sceptics, and certain intuitionists and subjectivists, nearly everyone agrees that knowledge is a function of the awareness of order. This order may be regarded,

as it was by Kant and the critical school, as reflecting a certain nature of the mind in terms of which we must think things. It may be regarded as a function of the nature of the self, as intuitionists like Bergson, and subjectivists like Mr. George M. Kalif, in his recent article entitled "The Metaphysical Foundation of Induction,[2] treat it. According to the latter, inductive discovery of relations is possible because of the persistence of the self. Such views lead to subjectivism or scepticism, for on the basis of them we may say either, that if there is something other than ourselves, we have no knowledge of it, or that nature is contingent upon ourselves.

On the other hand, we may take the view that the order which we discover in things really belongs to nature independently of our experience of it. This is not an uncommon position, being, in a certain sense, the point upon which all realists agree. But, the notion of an objective order is often regarded by members of this school as being connected with that of purpose, or rational direction. The French philosopher Cournot is a proponent of this position. If this general position is accepted, the problem of getting through to a reality which "lies behind" a phenomenal appearance falls away. That there are difficulties involved in accepting it, no one can deny—there have been too many outstanding and consistent idealists to make persumptous the claim that idealism is an impossible doctrine. However, both common sense and reason would be gratified if realism could be established upon an adequate basis. Even so, the problem of whether the objective order is also purposive or not would still remain an open question. In the remaining part of this paper I shall indicate the bases for my argument that it is reasonable to believe that the order in nature, which makes knowledge possible, is both objective and independent of the nature of our mind, and also that there is no need for going beyond it to a purpose, or to a designer which explains it.

It is perfectly possible to deal with the category of order or

[2] *Journal of Philosophy*. Feb. 15, 1934. In opposition to this view it has often been pointed out that the self is the most inconstant element in our experience, and is known only through the persistence of objects.

design without having to come back to the devices of a designing intelligence or to teleology. Before we go farther, it is necessary to state again just what significance the term design has in this connection. As it is used throughout this paper it is analogous with such terms as order, structure, pattern. Some such notion seems to be requisite to all practical and theoretical investigation of nature. Stating it more broadly, it is the notion of a relation of some or all aspects of reality in such a way that the discovery and analysis of one part, leads to the discovery and knowledge of other parts. Put in this way, the extensive limitations of this relationship are left undetermined, for to undertake to define them more specifically would imply that one had evidence as to the relative validity of the alternative metaphysical theories of monism and pluralism. This problem lies outside the province of the present discussion.

II

Taking the category of design as synonymous with that of order, it must now be shown that it is not subjective, and that it does not involve the notion of teleology. As Cournot puts it, it is almost impossible that our experiences should present themselves in the broad character of repeated patterns, unless such patterns were objective and independent of our processes of thought. This position cannot be given categorical demonstration, but it is so much more probable than the subjectivistic alternative, that we have good reason to believe it is true. It is very unlikely that the constancy of ordered relations is due simply to the constancy of our rational processes. Kant's formalism inevitably continues the eighteenth century tendency to bifurcate nature. The variable a priori presented by Mr. C. I. Lewis,[3] is a better suggestion, especially as regards the metaphysical implications of the problem, for, in so far as this variable a priori presents concepts related to the order of things, it represents the

[3] Prof. Morris Cohen suggests a similar notion in one of the papers in his recent volume *Law and the Social Order*, namely, "The Place of Logic in the Law," especially pp. 174ff.

constant checking of the thought and action of both the race and the individual by an unyielding reality. This process corrects and extends our concepts so that while each age has its uncriticized, a priori assumptions, those of any given period are unlike those of the periods which precede it and follow it; but they change on the basis of objective rather than subjective relations. That these relations present themselves in recurrent, identifiable structures is a point in favor of the realistic position.

The other extreme—subjectivism—is completely inadequate. In every statement of this position, having reduced the order of nature to a set of mental relations, it is immediately dragged around the house and into the back door, where it now appears as an objective system of relations under some such guise as God, or the constancy of the speed of light. In other words, neither Berkeley nor Eddington and Jeans, can deny the occurrence of experiences having an order the basis of which is objective.

Within the limits of a general relativistic philosophy, too, the epistemological problem is that of establishing the correlation between that which is reported in experience and that which is "really there." That is, the whole idea of knowledge as being more than a relationship between concepts—the purely formal notion—implies objectivity. If knowledge and experience involve order and design, if they involve a relationship the character of which is relative to both the knower and to the known, then, this order and design must be a part of the relationship. That this cannot arise wholly with the knower, isshown in the criticism of idealism. It might be possible in an absolute knower, but a doctrine requiring such a reality raises more questions than it can settle. It complicates rather than simplifies our problem, and on that basis alone may be seriously questioned.

Thus it is reasonable to believe that order or design in nature is objective, and the burden of proof rests upon those who challenge, rather than upon those who defend this metaphysical premise. Its defense rests admittedly upon arguments of probability, but a probability so well attested that we have reason to believe that it is true.

III

But this simply poses rather than answers the problem of teleology. Granted that the pattern of experience is the true reporting of patterns in objective nature, how does the order thus revealed arise? It must come either from some source external to itself—the extranaturalistic argument—or from tendencies which are a part of the same nature of things which the forms reveal—the naturalistic argument. The difficulty with the former is that it must explain the nature of that which is inexplicable. The moment any sort of an extranaturalistic thesis is set up, it is presupposed that an extranatural reality exists. Its function is to produce, to arrange, or to dispose the aspects of reality which we regard as natural. But on what possible basis can such reality be known? It must remain a gratuitous assumption, for, by definition, it is such, that acquaintance with it is impossible. The first difficulty of extranaturalism, then, is that of giving it significant meaning as related to reality. But grant that this can be done, the further presumption is that we can understand the way in which the extranatural acts upon the natural. Now this is unreasonable, for the necessity of setting up the extranatural is to explain those things for which our knowledge of nature cannot account. This means that the former must be essentially unlike the latter. In this case, we have no knowledge of how the natural order is affected by the extranatural, and no evidence that the natural order is a consequent of extranatural determinants. As far as knowledge is concerned, the only things that can affect natural reality are natural processes. We cannot imagine any relation between the natural and the extranatural.

The problem of design is in no wise simplified by appealing to the idea of a designer outside of the system. Such an appeal simply moves the problem back one step, for either the designer designs by nature, to use an Aristotelian phrase, or designs because of some still further removed insistence for design. If the former alternative is taken, it is just as reasonable to say that the natural order is the condition of its own design. If the other alternative is taken, one is involved in an infinite regress, and the problem

still awaits to engulf us; we have been granted only a temporary stay of execution.

In further objection, it may be pointed out that the area of the known is being constantly extended. What is extranatural to one age, is natural to another. Since incursions into the extranatural continuously reveal material amenable to natural statement, it would seem to indicate that what is still styled extranatural, may, with increased knowledge, be seen to be like that which we have already come to regard as natural. What this amounts to is simply to repeat once more that an appeal to ignorance proves nothing.

The naturalistic statement avoids all these difficulties because it has no need of the entities and processes which they imply. In the first place, it accepts the structure of things as due to the nature of the things themselves in the ordered relationship. It has no need to correct its inadequacy by a greater one. This is not to say that naturalism does not recognize limitations in our experience and knowledge. It does. But in so doing it rests on the probable belief that if what is now unknown, later becomes known, it can be dealt with in natural categories. In the second place, this position needs no outside agent to account for the fact of structure and design in the order of reality as known. An examination of a few instances of design in nature is enough to reveal the basis upon which this argument rests.

It is well known that any system of bodies tends to maintain its structure because of the mutual interaction of the movements and the directions of the elements composing it. This is true of the heavenly system; of a snow-flake; of ecological balance; and of social structures. In each case, the order or design of the system arises from its internal nature and relations, and not from external compulsion. It is natural that we should marvel at the neatness with which one form dovetails into the nature and needs of another; how a change in one part produces a compensating change in other parts. But in any system having design or order, this may be more reasonably dealt with in terms of the system itself than laid to the account of some agent external to it.

Thus it is indicated that while order, or design, is an important

element in the scheme of things; and may even be the basic category of a metaphysics which is both realistic—in the sense that the order of nature is objective—and rationalistic—in the sense that the genius of the mind is such that it is responsive to this objective order in things—it is not necessary to regard reality with its order and structure as being the result of a teleological propulsion which lies outside of it, either as a designing agent, or as an impersonal, but actuating force or principle. What order or design is found, may best be dealt with as a function of the system itself, taken as a whole; as expressing the balance of form which results from the mutual interaction of the elements which compose it. This view not only appears to be as able—indeed it seems to be more able—to deal adequately with the problems of metaphysics, but it has the additional advantage of being the simplest approach to this insistent problem—since it avoids the complicating consequences of predicating things of the unknown. As between opposing theories, each of which accounts for the relevant data, it has long been recognized that the simpler is more probably true.[4]

Knox College,
Galesburg, Illinois.

[4] I wish to make clear at this point that I am not shutting my eyes to the fact of purpose in human affairs. Certainly a good deal of the behavior of human beings, to say nothing of other biological forms, is directed toward ends and is therefore—by definition—purposive. This is sufficiently taken into account, however, when one realizes that this purposiveness is itself a function of the total situation in which the organism and its ends are found. The fact that we purpose one thing rather than another reflects the social structure in which we find ourselves. The fact that we are able to propose ends, and to attain some of them depends upon the organic structure which we bring to the situation. Again we are dealing with a situation in which the various factors are functionally related and require no "extras" from without the system to enable us to account for the changing pattern of the structure.

The point for which I am contending is that purpose is not only unnecessary but also leads to unfruitful complications when used as a metaphysical category.

On Space and Time as Attributes of Nature and Forms of Experience

BY

ARTHUR LAPAN

WHAT can we say of space and time when we consider them as attributes of nature and as attributes of nature in the context of experience? The following is an examination of this question in the light of those portions of the writings of Locke and Kant which were concerned with it. Since men have no difficulty in speaking about and utilizing the familiar spatial and temporal relations of things, we begin with these and shall avoid definition and debate except insofar as it is pertinent to the present inquiry. Nor shall we consider it necessary to examine space and time in any other context as, for example, that of modern physics. The familiar world is the necessary condition for the conception of any intellectual development of it, and to begin with the intellectual development is to render it unintelligible. This is evidenced in several ways. When we begin with physics and mathematics, we cannot account for the world within which we live and consequently end in scepticism about it, whereas this is not the case when we begin with the actual world itself. Furthermore, the manifestly perceptible is indispensible to scientific enquiry for we must employ instruments and objects directly accessible to experience. Without these there would be neither experiment, observation nor inference. Communication would be impossible without it as

well as discussion about subject matters such as logic and esthetics. It is for these reasons, therefore, that we begin with the familiar spatial and temporal relations of things.

The physical world, for Newton and Locke, was composed of indivisible, simple bodies in constant motion; and space was what held these bodies together. It was independent of matter and constituted a necessary condition of movement. The parts of space were inseparable (and consequently immovable) and without resistance. Extension, like motion and rest, number and solidity, was a characteristic omnipresent in bodies. It was consequently independent of us. Locke, unlike Newton, however, was not primarily interested in an analysis of the physical world. He effected a shift of emphasis from things as things to things as objects of the understanding. Heat, for example, is a mode of motion and subject matter for physics. But when heat is considered, not in itself, but as an object of the understanding, the theatre of enquiry has altered and it takes on new characteristics in virtue of the new context into which it has entered. The shift which was thereby inaugurated was one from the objects we experience to our experience of objects; or differently, from nature to experience. Since the physical world did not contain objects as we experience them nor our experience of objects, the existence of experience had to be accounted for. How is experience, and especially our idea of space, acquired?

The idea of space was produced by the contact of the body with the external world. These contacts, when conveyed to the brain and perceived by the understanding, were simple ideas of space. They were at once part of the subject matter of our knowledge and of the means whereby we know outer space; and this because knowledge of experience was regarded as preliminary to knowledge of nature. But these simple ideas, discrete and unconnected, could not yield us knowledge of outer spatial relations like distance, infinity and the like. Locke, therefore, endowed the understanding with the power of combining simple ideas into ideas of figure, place, infinity, and thus made knowledge of outer space possible. The understanding, however, could not transcend the

limits of its simple ideas; and was thus forever confined to the circle of its contacts with the external world.

In Kant, as in Locke, knowledge of experience was preliminary to knowledge of nature. Things in themselves were thereby rendered inaccessible and could not be known; and space, consequently, was put in the mind. But for Kant the problem was not so much whether space is an attribute of nature or of experience since the former alternative was excluded from the very beginning. It was rather: Is space the order of our presentations which later analysis discriminates or is it an antecedent condition of all possible experience? In the earlier portions of the *Critique*, at least, the latter position is dominant; partly because sensations were conceived to be void of spatial, and indeed every kind of order; partly to provide a ground for the universality of the propositions of geometry. If we begin with a world which is without form, structure must obviously come from elsewhere and for Kant the only possible source was the mind. Furthermore, it is only when space is conceived to be an antecedent form of intuition to which all possible experience must conform that geometry becomes intelligible. For we can then go beyond the experiences we have had to make assertions of all possible experiences; something we could not do were space merely the form of our presentations. In the latter portions of the *Critique*, however, structure is discovered in the fabric of experience and is not imposed upon it. The procedure is then analytic rather than genetic. We begin with the world as we know it and simply discriminate its various orders and characteristics.

Yet both the major propositions of Kant—namely, that space is an attribute of experience and that it is an antecedent condition of objects—are highly questionable. We perceive things and their spatial relations as independent of us; their extension is experienced as belonging to the things themselves. The extension is also a social object of knowledge and this would be unlikely were it merely a trait of experience. Furthermore, it is continuous with the effective world and the order of effectiveness, and inseparable from the instrumentalities whereby we attain our

ends. But the effective world and its order is in no way conditioned by us; consequently, space, from which it is inseparable, is independent of us as well.

Space must be introduced as an antecedent condition whereby things are ordered only if we begin with things as void of spatial order. But such a conception is unnecessary if space is continuous with nature. There is no function which extension can fulfill when conceived to be independent of nature which it could not fulfill when inseparable from it. Furthermore, the relation between space and nature becomes unintelligible, if space is taken to be a substance. How came these objects to be spatial and how came space to be applied to objects? Nor can we identify such a substance in experience for we cannot perceive things which are extended or extension separable from things. Language, too, has this bias. We say: "The table is wide," and the width of the table is not intended to be independent of the table. Space, in science, is not considered independent of the regularities and recurrences of nature since its laws are expressed in terms which involve spatial coefficients. Finally practical life is a testimony to the continuity of extension and nature. When we wish to attain certain ends we must modify definite spatial arrangements. A potter, for example, who works with clay, converts what was formerly incapable of containing water into something which now contains it and the difference, obviously, is in part due to the change its form has undergone.

Kant made space an antecedent condition of experience because he believed that only in this way is geometry possible. Yet the propositions of geometry do not cease to be necessary when we recognize that space is continuous with things. They then simply articulate the logical connections of things insofar as they are spatial and "space" denotes (among other things) the logical order of nature when it is regarded as spatial. Nature, under the attribute of extension, is the subject matter of geometry and the propositions of geometry are necessary because they state characteristics which are logically ordered. We say, for example, that the table is rectangular and that the diagonals of its tabletop are equal (using "space" in our sense of the word). Both

these statements imply one another so that it is impossible that the former be true and the latter false. The characteristics of things are logically connected when the propositions which state them imply one another; and the form of things is what they are said to be. It is in virtue of form that other characteristics can be deduced. Both the forms of things and their logical connections are inseparable from things themselves. There is consequently no need to conceive space as a substance in order to render geometry possible.

But as Kant has indicated, the propositions of geometry are strictly universal and this means that they must characterize every possible natural event. On what grounds, then, can we say that every possible event must be so ordered? In one sense, of course, this question is meaningless. The structure of things is the reasons for their being what they are and it is simply nonsense to ask for the ground of structure. Such a question arises only when we begin with a structureless world; and even then the existence of order is presupposed or the question would be unintelligible. The order of nature is omnipresent in it and the propositions of geometry are strictly universal because the structure of nature, when nature is conceived under the aspect of extension, is a necessary condition of things. It is that without which things could neither be nor be conceived. It is also a necessary condition for the order of nature when regarded in some other light. It would be impossible, for example, that things should be causally connected without spatial connections or that things should lack a geometrical order (we are now using "geometrical order" in the widest sense, as what is identical in the order of all the geometries) and none the less be causally ordered. So, too, where we examine the activities of things do we discover spatial connections inseparable from them. Nothing, indeed, could occur unless it had a spatial form. Structure, then, becomes, as it were, dynamic, and this is the most proper way in which to consider it, for it is nothing but the form of the interactions of things; the reasons for their behavior. Yet, there is no cause, in all that we have said, to elevate space into a substance. When extension is recognized as continuous with nature, the propositions of geom-

etry do not, therefore, cease to be strictly universal (i.e. when we do not confine the notion of "space" to "physical space" as conceived to-day).

So much, then, for space as an attribute of nature. What can we say about space when nature is considered in the context of experience? When we consider space in this way, of course, we are limiting discourse about space to discourse about nature in the context of experience; whereas, formerly, we limited discourse about space to discourse about nature. When nature is taken in the context of experience, it becomes an object of knowledge, significant and instrumental, for we interpret things to signify other things, actual and possible and utilize them to attain our ends. But space is a necessary condition not only of nature but of our experience of it. It is that without which things could not become objects of knowledge. What we perceive is always extended and external to us and both of these are spatial determinations. Space is also a necessary condition of experience when experience is taken as an organic response to the environment. Any study of the instrumentalities of perception, light, the sense organs and the nervous system, involves space. It is also necessary for the attainment of our ends and for the conversion of things into values. When the order of things is not appropriate to our ends we alter it, and this fact is so universal that it is difficult to exemplify it. A potter, as we have said, who works with clay, converts what was formerly incapable of containing water into something which now contains it and the difference, obviously, is in part due to the change its form has undergone. Finally, space is a necessary condition of knowledge. First, because the subject matter of knowledge is extended; and secondly, because what we know—namely, the intelligible world—cannot be divorced from the structure of space. In another sense, we can say that the subject matter of knowledge is what we do or may perceive, and this is extended; and knowledge itself is the logical development of what we perceive and clearly continuous with the perceptible. When "knowledge" denotes a process or procedure, it is as much dependent on extension for then the enquirer is in continual contact with what is perceived. The

perceptible world is both a stimulus to knowledge and a critic of it.

When space is considered as an attribute of nature in the context of experience, space becomes, as we have said, an object of knowledge. It then enters into an additional relationship and in that respect becomes subject matter for a new science. Whereas geometry studies the structure of space insofar as it is an attribute of nature, psychology studies it insofar as it is an object of experience, or an object of consciousness. In that sense space can be said to be mental or an idea. But our consciousness of space does nothing to space itself and it is, therefore, unnecessary to study space in experience before we can study it in nature. Proof of this is the procedure of the geometers themselves who do not make use of psychological material in their exploration of the subject matter of geometry. Further evidence is the lack of restriction which its independence suffers and the fact that its structure is not modified. Moreover, if space is a necessary condition of experience, how can experience alter it? I should like to add that when I say that knowledge makes no difference to nature I do not mean to imply that to be is the same as to be known; or that knowledge is identical with perception. In knowledge the reasons for things become articulate and reason is its proper object. But it does not follow that because knowledge concerns itself with one side of things that it therefore does anything to nature itself.

Although it is true that the extension of things can become objects of knowledge, it is not true, indeed it is meaningless to say that the function of things as an object of knowledge is extended. Space is an attribute of nature and as such can be known; but it is to speak unintelligibly to say that nature, when it functions in the context of experience, is extended. Can we say that the rôle of a thing as an object of knowledge is triangular? Or that the function of this thing as an object of knowledge is next to the function of some other thing as an object of knowledge? That they are five feet distant? Or infinitely divisible? As well say: "Triangularity is seven yards long." Propositions such as these are meaningless because they confuse what is appropriate

to one order of things with what is appropriate to another. Extension does not cease to be an attribute of nature when it is regarded as an object of experience. Further proof of this, if further proof be needed, is the fact that nature cannot be measured as an object of knowledge. We can, of course, measure the extension of things and represent it by numbers that are greater, less and equal to one another and can be added and subtracted. But we cannot measure the function of a thing as an object of knowledge. This, it seems to me, is but another way of saying what has often been said; namely that thinking is not extended and cannot be measured.

Although the treatment of time in Locke and Kant differs somewhat from their treatment of space, in essential outlines it is the same and we shall therefore pass it by for a discussion of time as an attribute of nature and as an attribute of nature in the context of experience. Time, like space, is an attribute of nature and for the same reasons: for we experience it as independent of us, as social, as belonging to things themselves, as continuous with the effective world and the order of its effectiveness. Again, it is inseparable from nature and its order is inseparable from it. The order of nature insofar as it is temporal is the ground of the necessity and universality of propositions like: if A precedes B, B cannot precede A. [Again, we are not referring to "physical time" of the physicists.] It is that without which things could neither be nor happen. It is also a necessary condition of experience for unless things endured they could not become objects of knowledge nor be known. Our utilization of things for certain ends, of course, requires time, for a misjudgment of the tempo of occurrences will compel a miscarriage in our purposes. Time is also a necessary condition of organic responses to the environment and can, and does become an object of knowledge. In these respects, what can be said of space can also be said of time. But when we limit discourse about time to discourse about nature in the context of experience, what we can say of it differs somewhat from what we can say of time in the context of nature simply. It is these differences to which we must now address ourselves.

Time, in a primary sense, is what we mean by change or what we indicate by the tenses of the verb. It is the actualization of

the structure of things and the interactions in which such actualization occurs. Time consequently is a passage from the unactualized (the potentially actual) to the actualized and from effectiveness to ineffectiveness. It is a process in which the future of the present becomes the past of the present. Such passage is, as we have said, a change or alteration. But when nature is taken in the context of experience there is no change or alteration. A thing may become an object of knowledge and cease to be an object of knowledge. But its function as an object of knowledge does not alter its temporal context. In that respect it remains the same. The flower before my gaze may alter and become different; and I may and do note these alterations. But the function of the flower as an object of knowledge does not alter while I look at it. It is this, I think, which Locke meant when he said that "Ideas, however made, include no sense of motion." Another way of saying this is that a thing cannot be more or less of an object of knowledge. Ideas, in other words, come into experience and pass out but they do not change their function as ideas, however much the things whose ideas they are change. Of course, as our knowledge augments, the thing, when it enters into experience, may take on greater significance or meaning. The logical connections which then it has, for us, augment as well. In this sense, ideas (or things become significant) do change. For they then connote not so much things that become objects of knowledge as they do the rôle of those same things in the process of knowledge. In the second context the idea alters since its function in the process of knowledge changes with alterations in the relevant body of knowledge.

Time also denotes the succession of things and the fact that they come before and after one another. When so construed, of course, it is impossible that things which precede one another should at the same time follow them; and it is also impossible for A (let us say) to precede B and for B to precede C without A preceding C. When things function as objects of knowledge, they exhibit this same temporal order. If A precedes B as an object of knowledge, then it is impossible that B should precede A; and if A precedes B as an object of knowledge and B precedes C, then A precedes C as an object of knowledge. The temporal order of

our ideas is, of course, grounded in the temporal order of nature. A becomes an object of knowledge in the response of the organism to the environment and so, too, B. If the response in which A became an object of knowledge preceded the response in which B became an object of knowledge, then obviously the latter response could not precede the former. Consequently, A, as an idea, must precede B as an idea.

But there are here two distinct orders of succession. Although A may precede B as an object of knowledge, it need not precede it in nature. I may know the son before I know his father, but the father came into being before the son. The succession of things in nature and their succession in experience need not, therefore, be the same. The same thing is true of the duration of a thing and its duration as an object of knowledge. The duration of the star and the duration of our experience of it, for example, are not necessarily the same. The star may endure even though we do not sense it and its existence is uninterrupted while our sensation of it may be discontinuous. The reason for this is apparent. The star is an object of knowledge only as an experience and the duration of the star is an attribute of the star in the context of experience when it is an object of knowledge. The duration of this experience would therefore be independent of that segment of the duration of the star that is simultaneous (regardless of the definition of simultaneity) with its being an object of knowledge, and might precede or succeed its natural duration indefinitely.

It is clear, from all we have said, that space and time as attributes of nature and as attributes of nature in the context of experience are not at all the same thing. Both are attributes of nature; but the function of nature as an object of knowledge is not extended; and although this function is temporal, what we can say of it in that respect is not identical with what we can say of time when it is simply taken as an attribute of nature. Space is a form of nature (in or out of experience), but not of experience. Time is both a form of nature and a form of experience and the two forms are distinguishable.

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Things and Potentiality

BY

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IN *Physical Theory* Mr. Lenzen writes, "Thus the concept of thing is the concept of a class of aspects which are in the past, present, or future for several minds."[1] Again, in *Mind and the World-Order*, Mr. Lewis defines "thing" as ". . . a complex of properties or qualities, recognizable by some uniformity of appearance."[2] Without questioning the metaphysics implied in these two definitions of "thing" I shall accept them as quite compatible and as useful in defining the rôle of experience in the construction of scientific objects. If in "Pragmatism and Metaphysics"[3] Mr. Morris has not established proof of the existence of objects independent of any and all experience of them, he certainly has shown conclusively that the possibility of experiencing objects is independent of any and all observers.[4]

All of the above mentioned writers have attempted to show that the concept of *thing* arises out of our experience and that both epistemological and metaphysical dualism are no longer problems. Furthermore, all have come to a common agreement (that is, in

[1] *Physical Theory*, P. 7. Mr. Lenzen says also, "The proposition that a thing exists means that certain correlations of aspects may be experienced." Ibid., p. 7.

[2] P. 137.

[3] This article may be found in *The Philosophical Review*, 1934.

[4] To say "the possibility of experienced or of experiencing objects exists" is quite different from saying "objects as experienced exist independent of an observer." For to say that qualities of an object exist potentially, makes allowance for the place of experience in the formation of the concept of *thing*.

so far as they have developed their theories) in their contention that a *thing* consists of its present and possible aspects, all of which are verifiable through experience. The purpose of this article is not to define further the *thing*, but to show how the concept arises in our experience and to show what is implied in attributing aspects or characters such as color, roundness, sweetness, and etc. to things, and to illustrate more clearly the meaning of potentiality from the experiential view of the rise of the thing. These two problems have been stated together purposely, for, as will be shown later, their solution seems to be closely related.

First of all we might ask, What is the difference and the relationship between aspects or characters and things? Since the concept of a thing extends beyond that which is immediate in experience one cannot hold that the concept arises upon the presentation of any particular experience, whether, it be of touch, sight, taste, or any other. Furthermore, since aspects,[5] qualities, properties, and characters already imply that they are aspects of some *thing*, we are not justified in saying that these features arise before the emergence of the concept of the thing by virtue of which they exist as aspects. Hence we are driven to the conclusion that unless a given datum signifies other data to be experienced in an orderly manner in some future relationship, it does not become an *aspect*. As soon, however, as a given datum signifies future experiences which arise in an orderly manner because of our own behavior or because of changes quite external to us, we are in the strategic position of forming the concept of a thing whereupon the data, past, present, and anticipatory, become aspects of that thing.

It is not enough to say that when we have found order in the appearance of certain data we have arrived at the concept of the thing. Such a version would be interpreted as merely positivistic and would not permit the *concept* of *thing* to which these data are returned. Rather a thing or a scientific object is centered about a certain kind of datum, namely the sense of touch which implies pressure and solidity. The sense of pressure and kinesthetic

[5] "Aspects" will be used throughout the remainder of this article as synonymous with "qualities," "characters," and "properties."

sensations, as pointed out by G. H. Mead,[6] are the means by which we attribute an inside to a thing. By pressing one's hand against an object one recognizes that the touched object offers the same type of resistence and gives the same kinesthetic sensations as did the other hand when pressed against the former. Hence we recognize that an external object is a substitute for our own body in so far as it produces the same results. By virtue of this substitution we are able to infer that surfaces detected by the sense of touch have insides. Although our own bodies have other characters which inhere in objects, such as color, odor, taste, etc., none of these can be identified with the responses which they call out, either in our bodies or in other objects.

It is the present contention that the inside of the thing, detected by means of kinesthetic sensations, is that to which all aspects are ultimately referred. In projective geometry and in viewing a penny from different perspectives these various perspectives lead to the same spatial locus. In fact a physical theory of the reflection and projection of light would be quite impossible without the conception of a common locus of the various kinds of sense experience. Scientific control presupposes a definite spatial locus of all things produced or controlled; a spatial locus of the causes (external) of sense experience. A mere succession of experiences would not permit their control, nor would then any experienced quality be an aspect of a thing. In fact aspects belong to the object (as over against the subject) because scientific control directs its activity toward a something having an external spatial locus.

The concept of *thing*, we claim, is more than a recognition of data that appear in a definite order. These data must become aspects or qualities, and before they can become such they must have a definite spatial point of reference. That experience is a sense of pressure found in touch, and it is because it is employed in testing the validity of all other experiences and finally essential in controlling the order of other experiences that we refer to it as the "soul" of the thing of which these other experiences are aspects. By this it is not to be understood that the sense of

[6] G. H. Mead, *The Philosophy of the Present*, see "The Physical Thing," p. 119.

touch or kinesthetic sensations are metaphysically different or more real than any other type of sense experience. It is meant simple that all physical theories of sound, light, etc., are based on this fundamental assumption. A merely positivistic interpretation of presented data would not permit a common locus of experience and, hence, would not permit the rise of *aspects* of *things*.

Mr. Lewis writes, "For the passive being, the *only possible* passage of experience is the actual one; the only continuities of reality—the only relations with any given—would be the actual flux of experience. This statement refers to the passivity of consciousness, but it might equally well refer to the action of our bodies or to bodies external to us, for, as Mr. Lewis would agree, it is because of relative changes of position of the perceiving organism with reference to our environment that we have *different* given data at all. We are active creatures and it is due to this fact that given data signify future experiences and that a *thing* has meaning. If it were not for the possibility of relative change of position of our sense organs with reference to other objects, the knowing process, meaning, and verification would be impossible. By reason of this fact, on the other hand, we are able to predict and control our experiences and verify our predictions.

The contention that pressure is an aspect of the thing, yet an aspect to which all other aspects are referred as a common locus is at the basis of modern experimental and creative science. It is generally agreed that change implies something that is stable. For this reason scientists have conceived of atoms, electrons, and protons, as stable, the ones chosen as stable depending on the purpose at hand. The experience of changing things is referred to a bounded volume offering a pressure similar to that experienced in touch and responsible for the various experiences of the thing under observation, whether the thing be a galaxy or an electron. Even with the electro-magnetic theory of matter, matter has a locus of action (a field) and exerts a force or a pressure. The scientist and the producer are interested in things as bounded volumes because they are the means of producing and controlling all other experiences. Because the resisting volume

is central in conduct (that is, because it is a means of prediction, production and control) it is selected as that experience of which all others are aspects methodologically. It is the thing to which systematized data are returned as aspects.

To think of the meaning of the thing as consisting of actual and possible aspects requires a clarification of the concept of possibility or potentiality. Since the concept of *thing* is dependent on experience, the potentiality of a thing must be defined also in terms of experience.

For Aristotle matter as such was pure potentiality because it had the capacity to take on form. The particular form that matter received, however, was due to an unfolding of that form which existed potentially in the matter. E.g., the oak was potentially in the acorn. Likewise the velocity of a falling body, for Aristotle, was due to the inherent nature of the body, and bodies of different sizes, if of the same material, were potential of different velocities in a common medium. For Galileo, however, velocity and weight were defined externally and were due to a relationship between masses. Although velocity and weight for Galileo were characters of mass, they came about by virtue of relationships external to the mass as such. A definite determination of these characters involved more than the inherent natures of masses; these characters were determined by the environmental circumstances as over against a potency resident in the masses as such. E.g., $V = gT$ is a formula describing the potential velocity of a falling body. If there is a similarity between the potentiality as conceived by Galilean or Newtonian physics, which has dominated modern experimental science, and the Aristotelian potentiality, it lies in the fact that for both, matter is capable of acquiring certain characters. The causes of the acquisition of the characters are differentiating factors for each. The determination of the characters of a body or a thing by the specific environment of the thing, that environment including the human organism, demands a concept of potentiality wholly in terms of the factors essential to that determination since the thing too, of which these characters are a part, is a product of that environment. This does not mean that the characters ex-

perienced by the percipient are returned to the "environment" as such, for that again would be a purely positivistic point of view. Rather, characters that arise because of an environment are given a definite locus. Just as weight, which is due to a relationship between masses, is a character of a *specific* mass or body, so color and other experiences witnessed by means of our senses are characters of things. What is meant, then, by saying that color, and other characters requiring a percipient organism, exist in things potentially and, secondly, what is meant by saying that a thing consists of its present and possible aspects, from an experiential standpoint?

Since the concept of a thing includes a meaning which extends beyond the presented aspect we are wont to say that the unpresented aspects, verifiable by future experience, are potentially present or exist potentially. Just as a mass has potentiality with respect to a definitely assigned point of reference and by virtue of a definite position, so we may say, from an experiential point of view, that an object now unobserved is potential of characters which are acquired when we bring ourselves in the position of observing it. This does not imply that physical objects do not have an existence independent of observation and that there are no relations independent of observation, for there are physical and chemical relations between bodies which exist independent *of* observation but can be proved to exist *by* observation. For example, a falling body is accelerated independent of our relationship with it and the evidence for that independence is experimentally verified. Nor can we conclude that characters are always present in objects and that only the experience of them exists potentially. Since certain aspects of things are due to a relationship between the thing and the percipient organism both these aspects and the experience of them exist potentially. And just as certain activity must occur before the potentially energy of a physical body is actualized, so activity is presupposed in the actualization of any potential experience of a thing. Certainly this does not mean that one has no experimental evidence for, say, the existence of the sun after it goes down, for the relation-

ship of the sun to the solar system is one which can be verified just as easily without seeing the sun.

Since, then, the aspects which a thing acquires are dependent on relationships with other things, we cannot determine potentiality by studying the thing in isolation. It seems, therefore, that the potentiality of a specific thing is known only when we have stated the law which the thing in question follows. Once more, to give a statement merely of the order of succession of experiences will not permit the concept of potentiality, for without law it would not permit things of which these aspects are possible.

To say that a thing is potential of certain aspects or ends means, in experiential terms, that we are able to predict and, very often, control the conditions necessary for the actualization of those aspects. For example, to say that water is potentially ice or steam implies, from the standpoint of science, a statement of the conditions under which it may become such. Or, to say the fertilized egg is potentially a flying organism means that under certain conditions this will be the case. Or, again, to say that the earth is potentially a cold, lifeless body implies, from the scientific standpoint, a theory predicting such an outcome. All of these potential aspects belong methodologically to the spatial locus of prediction and control, that is, it is the manipulated object to which the potentialities are ascribed.

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Organismic Logic in the History of Science

BY

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THE logical pattern underlying twentieth century science is strikingly uniform from physics through biology and psychology to social science. Our purpose will be to analyze and illustrate this pattern, to trace its development, especially from the Middle Ages to the present time, and to suggest some possible consequences for the future.

The pattern is organismic in that the major interest in science as a whole lies in the part-whole relation. Accordingly, the contemporary movement is expressing itself in the following different ways: in physics, e.g., an emphasis upon systems, fields and "wholes," method, and the discovery (or rediscovery) that physical nature is *organic*. In chemistry we find a similar trend, although not so marked, e.g., in the breakdown of elementarism (isotopes, radiation phenomena) and the like. In biology, the outburst of organismic fact and theory has been tremendous. In psychology we need mention only the *Gestalt* and culture psychology movements. In social science, historians, cultural anthropologists, political scientists, sociologists and economists are turning to instruments of a similar logical character—fields, wholes, patterns, gradients, transformations, conservations and other concepts of dynamics.

Some tentative conclusions. The *organic* turn that contemporary scientific thought has just taken is based both on fact and

theory. But the status of science from which it is a violent reaction, as everyone thought at the time, *was based on fact.* This is truly astonishing. What business has science to rely on facts if its whole structure must collapse—that very structure which fact seemingly required? No wonder that scientists are now trying to find out, "What is a fact?"

1. So-called inductive scientific facts are not such data as speak for themselves. The breakdown of mid-nineteenth century science all along the line proves this point indisputably.

2. Logic and science are not divorcible. Deduction is as necessary a scientific tool as induction.

3. Science lost something that was most vital to its own success, *as science,* when it officially broke away from philosophy. But actually, under psychological laws, the break could only be apparent. Science is as subject, in principle, to empiricism *versus* rationalism, as philosophy itself. Both fluctuate together.

4. Even science, ethics and art have been artificially separated during an age of specialization.

5. Scientific theory has had a strikingly cyclic history. At 1250, 1650, and 1820 and now at 1935 it is organismic in intent. All previous organismic movements collapsed because they were vitalistic. Between these peaks, the thought-pattern swerved to an opposite extreme, that of mechanism, whose peaks fall at about 1400, 1775 and 1860.

6. *This oscillatory character* (which has been accelerating) *is being resolved into an organismic position that is neither vitalistic nor mechanistic.*

7. If we consider 300 B.C., 1250, 1650, 1820, and 1940 as the pre-organismic and organismic peaks, respectively, the cycles have been shortening roughly, by the fraction 1/3 to 1/4, but that the last two spans show a certain lengthening, probably due to institutional lag. It would seem possible, in spite of the complexity of the problem, to predict another return to atomism. The peak of the swing may fall between 1950 and 1960.

8. The shifts to mechanistic patterns of thought in the past were demanded by pressing, human needs: (1), the need for religious emancipation, (2), for political, and (3), for politico-

economic freedom. Under these circumstances, a unified culture-pattern, *to which science is subordinate*, concentrated upon elements, parts, substance, individuals, nationalisms, aggression, competition, force, revolution, and war. During these periods scientific theory was relatively unproductive. The next swing will be due to the fact that still another major period of civil war will be necessary before the emancipation of the individual will be complete.

9. Current views trace back on the whole through the pre-organismic movements of 1820, 1650 and 1250. Little theory, common to the present trend, can be found in the thought-patterns of 1860, 1775, and 1400.

10. Mechanistic science has been barren in theory, but has served, during social revolutionary periods as a *motive* for much needed reform, by supporting the need for concentrated study of the "part," the individual. These movements, characteristically, have denied the existence of primary wholes. Mechanistic science has also served the excellent purpose of inspiring a wealth of valuable, indispensable work on structure, morphology, minute and accurate analysis, upon which to build the next story of the scientific edifice. At the same time, however, it has promoted fallacious scientific theories.

11. We are now climbing to an organismic peak. The present confusion is due to the inertia of mid-Victorian science and ways of thinking, which are resisting the swing of the pendulum. Scientists who are now living have lost continuity with the main developments of scientific thought because they grew up in a mechanistic period and were trained in an educational system conceived and executed during a mechanistic wave. During these periods interest in historical continuity declines, and science picks from the records and achievements of its masters, only quantitative data. The *thought* of the masters is neglected, deleted, distorted or forgotten. We are now in the process of undoing what mechanistic theory did from 1840 to 1890, and in picking up the lost threads, as our avalanche of histories shows.

12. Scientific and social progress has always been retarded by the atomism of over-simplified ways of thinking and observing.

The naïve mind reverses the order of nature, seeing and comprehending those facts and events first which, genetically, occur in nature, last. It sees the parts first and erroneously supposes them to be primary under natural law, when in reality they are secondary.

13. The periods around 1250, 1650 and 1820, and 1935 (especially the latter two) are characterized by the following features all of which become clearer as we advance down the centuries, and *all of which belong to the same thought-pattern.* If one feature stands out, so do all the others, for they constitute a single, logical unit. Relativity; part-whole relation; subordination of parts to their wholes; emphasis upon form; pattern; system; maxima and minima (as laws of an absolute organization or system); fields; unity of plan; universal laws; certainties; derived properties; generalized scholarship; deductive-inductive methods; rationalism; teleology; organic conception of society; cooperation; socialism; internationalism; peace; harmony; primacy of wholes; oversummative wholes; interest in method; faith; optimism; tolerance. Reason and intelligence dominate.

The periods around 1400, 1775 and 1860 are dominated by the opposite culture-pattern as a whole. Absolutism; aggregates; elements; parts; substance; innate properties; a fortuituous, planless world, lacking form; derivative character of wholes; special laws for each subject; induction; empiricism; specialized scholarship; individualism; laissez-faire; imperialism; expansion; revolution; war; conflict theories of evolution; denial of teleology; linear and summative totalities; little interest in methodology; skepticism; mechanism; atomism; romanticism; voluntarism; pessimism; distrust; nationalism; utilitarianism; hedonism; and Epicurianism. Feeling and will dominate.

14. *Finally, the resolution of the antithesis between vitalism (the whole is primary) and mechanism (the part is primary) is synchronous with the stabilizing of society because the two are aspects of the same, unitary, culture-pattern.* The resolution is *not* being achieved by an eclecticism, for the logic back of vitalism and mechanism is mechanistic. Rather, the resolution is a case of a universal evolution or maturation of human intelligence, a passing

beyond assumptions of the past to the grasping of a larger, more general and comprehensive whole in which the problems faced heretofore by vitalism and mechanism are seen as one.

15. In order to see clearly, why science is now turning *organismic*, it is necessary to look at history as a whole. Such a perspective shows us that the main problem of science, any science, always has been to solve the part-whole relation, the problem of the many in the one, of pluralism and unity, of permanence and change, *of the rôle played by the part in the whole.* In philosophy the problem is that of the particular *versus* the general. In physical science it is the microscopic *versus* the macroscopic, the atomic *versus* the molar, the behavior of the part under the dominance of the whole, while the part still possesses "degrees of freedom." In biology it is a problem of how the parts of an organism function with reference to the order, organization and economy of the *whole* organism. The same problem transposes to the field of ecology.

In psychology the same issue is still uppermost: figure and ground in perception; the rôle of a particular feeling or attitude in the maintenance of a balanced personality as-a-whole: the problems of social adjustment; the relation of an individual, a part, to the social group, a whole. In economics the problem is the relation of individual productivity to the balance of the economic structure—production *versus* distribution. In political science the problem is the relationship of the individual to the state. In ethics and jurisprudence it is a question of individual rights *versus* the rights of the social group. On a world scale, the question of nationalisms *versus* internationalism reveals the same pattern.

I. 1250–1900

The Medieval Enlightenment. So it was around 1250. The main theoretical problem of Scholastic thought was realism *versus* nominalism. Wherein resides the ultimate truth, the ultimate reality, in the general and universal, the whole, or in the particular and individual thing, the part? This was a most crucial problem, indeed. If reality resided in universals, and particulars derived

their ultimate significance from them, the Church, which purported to symbolize a Universal God and His authority, stood on impregnable ground. It possessed a sanction, a sovereignty over men. On the other hand, if reality accrued only to particulars, and the general was only an idea existing in so many separate and unrelated minds, there could be no absolute, universal and transcendent reality. Religion, God and the Church were artifacts, sheer illusions.

It is not surprising that discussions became intense. Compromises were not convincing, and for good reason. Thought was too absolutistic and atomistic to solve the part-whole problem. The solution demanded an abandonment both of mechanism and atomism (the particulars, parts, or elements are the source) and of vitalism (the whole is external to the parts but still controls them). The concept of a *relative-absolute* was necessary to resolve this antithesis, and the relative-absolute is strictly a product of twentieth century thought. Even so, modern science is returning to 1820, 1650, 1250, even to 300 B.C., in its emphasis upon *form*. Form is the relative-absolute! But for Plato, Aristotle, Thomas Aequinas, Leibnitz, Spinoza, Kant and Hegel, *form was absolute* and hence the part-whole problem was not solved. Today, it is still absolute, *but it is also relative*, for it can change and yet not change, be curved and straight at the same time; simple and complex at the same time; it is transposable and conservable; it can disappear and reappear without losing its identity or continuity. The discovery of unified, dynamic but complex wholes, which *include* their parts, in short, the truly organic whole, the "Gestalt," awaited upon a truly relativistic age.

1250 to 1650. The rise of economically independent cities, princes and kings, in short, the stormy rise of the modern political state, resting upon a mercantile system and exploitation, together with the religious revolution, pre-empted human effort for nearly 400 years. Scholarship in terms of science and philosophy sank into another dark age.

Art, then literature, naturally, preceded the scientific and philosophical awakening, for initial insight is always a matter of perceiving *total situations* by unanalytical, feelingful, intuitive methods. Art and literature herald new eras.

Scholarship revived to some extent in the Sixteenth Century, but we are interested more particularly in that glorious sixty years from 1630 to 1690: Galileo, Descartes, Harvey, Malpighi, Newton, Huygens, Leibnitz, Fermat, Roberval, John Bernoulli, Althusius, Grotius, Pufendorf, Campanella, Cumberland and Cudworth. When we inspect this scholarship at a single glance, comparing the type of achievement in one field with that in another, a simple pattern of thought can be seen to transpose across the entire enlightenment. Galileo was thinking in terms of a simple, restricted type of relativity. A constant, transposable relationship between moving bodies and their fields lay behind his concept of falling objects. His principle of similitude which, he saw, applied to physical and organic nature, alike, was a stroke of genius that only now is being appreciated. Ernst Mach and Herbert Spencer called attention to it. More recently D'Arcy Thompson has revived it in biology. This principle is distinctly one that applies to *organised wholes*.

Descartes was interested in the properties of points as determined by their coordinates. His problem in philosophy was to explain how the Universe of body and mind could constitute a unity after he had sharply separated them by definition. Harvey's revival of epigenesis demonstrated that for him the problem of growth was one of the unified organism as a whole. Malpighi was concerned with the rôle that different parts of the body played in keeping the body alive. Isaac Newton was thinking in terms of a universal system or order of nature when he conceived his principle of gravitation and laws of motion. He was not unconscious of relative *versus* absolute motion, nor, when his work was done, did he refuse to consider nature as teleological in plan. The interest, all during this period and on into the eighteenth century, in maxima and minima, especially in the principle of least paths (least action), rested upon a general belief in design. Least action for Maupertuis, Euler and Leibnitz was evidence of divine purpose. It indicated a universal principle of perfect and absolute organization, a constant part-whole relationship.

So, too, in social theory, the outstanding problem was one *of the part in the whole*, a problem of "membership character" as the

Gestalt psychologist would say to-day. The spirit of Grotius, Althusius, Campanella, and the earlier Physiocrats was socialistic. What is the relation of the individual to the state. Is the state itself a reality or a man-made artifact? From what source does law receive its sanction? Bodin had already attacked the problem of sovereignty. Society is for the most part seen as a dynamic, disequilibratable unit, an over-summative whole. Thus, the mid-seventeenth century mind universally saw form, pattern, order, harmony, plurality within a unity, even if the problem itself was far from solved.

By 1740 the thought-pattern of 1650 had practically disappeared. The fact that twice, since then, it has returned (1820, 1915) is proof enough that it did not collapse because its fundamental inferences were unsound for all time. It was not abandoned because relativity was wrong.

The culture-pattern collapsed again for the same reason that it broke down after 1250. The wholes of which human beings were the parts were living demonstrations of a fundamental law of nature, that wholes control the activities of their parts, whether physical, biological or social, or else the whole disintegrates. The mediaeval church controlled even the consciences of men. But there was another law of nature that the mediaeval church did not understand, namely, that *wholes evolve, including their parts*. The vitalism of Scholastic thought, in which the whole is external to the parts, prevented it from being realized that in reality *the whole includes the parts*, and that, in being determined, the parts, therefore, *share* in the process. At the social level the participation has expressed itself in revolution. In short, when the control of the whole over its parts becomes tyranny, the parts emancipate themselves and "close" into new wholes. Thus in the 15th and 16th centuries the social whole is changing its form from a clerical to a secular state.

But the secular whole repeated history. The seeds of a mechanistic position had already been sown by Descartes' dualism and by Francis Bacon, Hobbes, Gassendi, and J. B. Van Helmont although Hobbes' writings contained many organic implications, even to analogies between the state and the living organism. In

1664 M. C. de la Chambre wrote a mechanistic, atomistic account of the human mind. Boyle, like Descartes, was in part a dualist and atomist. In 1671 Richard Cumberland introduced a utilitarian ethics that anticipated the depths of materialism one hundred years later. In 1672 le Vayer anticipated the skepticism of Hume. Locke, although an empiricist, accepted "reflection" as a formative principle and opposed Hobbes' position that the "state of nature" was universal conflict. Leibnitz's monadology was symptomatic of the future.

By the time the eighteenth century opened, mechanism and materialism were in full swing. In 1704 we find Pierre Bayle, the skeptic; in 1705 Mandeville contended that selfishness worked better than benevolence; by 1710 George Berkeley had constructed a thoroughly mechanistic system of psychology in subjective language; in 1713 an anonymous publication purported to prove that sensations and ideas originated from brain fibres. There were also the less known materialisms of A. Collins and A. Collier. In 1715 Leewenhoek favored preformation, a mechanistic position in embryology; in 1720 John Toland proclaimed that thought was merely a motion of the brain; in 1728 Peter Brown eliminated from Locke all vestiges of rationalism. The phlogiston concept was under way (Stahl). We have a mechanistic faculty psychology, a chemistry based on substance, a biology based on anatomic structure *and the last of geometry for 60 years*. Mathematics concentrates upon infinitesimals and probabilities.

In 1747 we approach the depths. Zanotti published a rank materialism; de la Mettrie (1748) pictured man as a machine; we are in the period of Hume, the empirical skeptic and associationist. Psychology becomes extremely mechanistic in the associationism of David Hartley (1749). In 1750 the behaviorist of the period appeared—Robert Whytt— who denied the "sentient principle" previously admitted for living organisms. We have in 1754 de Condillac's empty mechanistic sensationism; in 1755 Hutcheson's utilitarianism; in 1758, Helvetius, a follower of Hobbes and Mandeville. In 1757 Albrecht v. Haller methodically paved the way for a purely mechanistic physiology, al-

though, himself, tended toward vitalism. In 1760 came Diderot and his Encyclopedia, in 1762 the individualistic, romantic Rousseau; in 1764 the biological atomist, Bonnet; and in 1776, Adam Ferguson, another utilitarian. In 1772 came Joseph Priestley for whom substance was primary in chemistry and mental elements in psychology. There was Lavoisier who overthrew the phlogiston theory only to repeat the same type of error (the substance error) in believing that oxygen was the basis of acids. We reach the bottom in the 1770's, perhaps in 1776, with Adam Smith's Wealth of Nations. (Our characterization in no way detracts from the humanitarian purpose and influence of this whole period.) A long list of mechanists in every field could be cited.

Already, a minority of minds has been skipped, that still worked with the thought-pattern of 1650, refusing to abandon the problem of form. But, during this period, these men were, on the whole, repudiated. They were Spinoza, Christian Huygens (with respect to organic, wave theory of light), Ralph Cudworth (Socialistic thought); Nich. Lemery (in his emphasis upon chemical form); Borelli (principle of similitude applied to organic growth); Brunner (who opposed preformation); Leibnitz (in his stand against Descartes); Hartsoeker (opposed preformation); Joseph Butler (who in 1726, maintained a magnificent stand for organicism); Euler, whose theories in mathematics were unintelligible to many of his contemporaries; Maupertuis (least action, defended by Euler); Buffon, the biological vitalist who defended epigenesis; Wm. Porterfield, (eye, vitalist); Boscovitch with his force atom; Robinet (unity of plan in the organism); Becarra the humanitarian criminologist; Abraham Tucker (a pre-organismic psychologist); J. A. Unzer in physiology (vitalist); Samuel Farr, a biologist who rebelled at making the organism a mechanical, passive victim of environment; Pirri (opposed to preformation); Wenzel in chemistry (mass action); Guyton de Morveau who declared for the principle of the unity of matter, and that form influenced affinity; Bergmann who held that form partly determines chemical reactions; Blumenbach (epigenesis); Alexander Monro (opposed the "conditioned reflex" type of thought

in physiology); J. G. Herder, the philosopher of History, and finally, Immanuel Kant.

By now we begin to breathe the deeper spirit of the early nineteenth century. Kant may be considered the leader. But there were Goethe, Thomas Reid, George Prochaska, de Jussieu the botanist, Kielmeyer in morphology, Erasmus Darwin, Fichte, Autenreith, Schelling, Xavier Bichat, and Berthollet (whose chemical theories were not understood for 40 years) all of whom usher in a period hardly less glorious than from 1630 to 1690.

Form returns. Rationalism and idealism in philosophy, idealism and the socialistic point of view in ethics and political theory, unity of plan and teleology in biology, interest in integration and coordination in physiology, *field concepts* in physics, *form* in chemistry, the *ego* in psychology, and *geometry in mathematics*, all testify that the part is being studied *in the whole*, again. Once more the whole comes first, parts are derivative, absolutism gives way to pre-relativity, romanticism to reason; blind induction is guided by thoughtful deduction.

The century opens in philosophy with the well known followers of Kant. Biology has its Cuvier, Geoffrey St. Hilaire, Lamarck, Johannes Müller, von Baer, and E. H. Weber, all of whom emphasized, in one fashion or another, the problems of form, whole, integration, coordination, unity and continuity of plan. Some, like Cuvier, von Baer, and Johannes Müller swung toward vitalism; others, like Charles Bell, Gilbert Blane, and Purkinje toward mechanism. Usually it was a British scientist who swung toward atomism, in the British empirical tradition. For the most part the vitalists were European, following the continental rational tradition.

Turning to physics, it is consistent with the swing of the pendulum that the wave theory of light should return (Thomas Young) and supplant the atomistic, corpuscular theory. But more striking was the beautiful work of Oersted, Faraday and Lenz who brought in field concepts (especially in regard to electrostatic and electromagnetic fields). Pattern, form, and system take the place of substance, phlogiston and caloric. One should mention the contributions of George Green in applying the con-

cept of potential to problems of electricity—a relativistic approach —also Gauss's principle of least constraint and his work on fluid equilibria. The conservation laws were born in this period (mass action, maximum work, Lenz's law) and finally the principle of the conservation of energy (Mayer). Wherever conservation, transformation, field theories, maxima and minima, and waves, are emphasized, *we know that the scientific mind is thinking in terms of wholes and part-whole systems.* It is to that extent an organic and relativistic period.

Chemistry gives us the same picture. Berthollet was active (mass action and maximum work). Wallaston was basing chemical properties on the form or relative arrangement of atoms in patterns. Form was important in determining the chemical reaction. It is no accident that at the same time when Cuvier was studying the part-whole problem relative to living organisms, Avogadro should be differentiating the atom from the molecule. Avogadro, also, thought of fundamental chemical phenomena like acids and bases, relativistically. The relation of one to the other *defined them.* Their properties were not *innate.* Oersted, likewise, defined acids and bases relativistically, as did Sir Humphrey Davy in his earlier years. Later, however, Davy accepted a substance concept—that acidity was due to hydrogen. Widespread acceptance of this view in its modern form is probably traceable to Liebig whose thinking was clearly atomistic and absolutistic and did not belong to a relativistic period. The atomist of this period, John Dalton, was not a complete atomist. Nevertheless, his views were not well received at once, especially by Davy. While the atomic theory was useful in ordering a vast array of detailed fact, Davy and many other chemists seemed to foresee what might easily happen, and did happen. The theory turned into an "ism," a philosophy of nature.

Gay-Lussac also emphasized form, in chemistry, and regarded relationship as the important problem of acids, bases and salts. Mitscherlich was saying that crystal form did not depend upon substance, and Haüy had already made his pioneer contributions. Today, chemistry is nearer the thinking of Oersted, Avogadro and Berthollet, than it has ever been since that period. It is also

in keeping with this period as a whole, that N. L. Sadi Carnot adumbrated the second law of thermodynamics and discovered the irreversible heat cycle.

In psychology, again, exactly similar events were occurring. It is irrelevant that they did not result, immediately, in the engineering of human nature. Kant and Fichte had already reacted against the atomism, especially of the more famous British Associationists, but Germany had had its own independent, mechanistic debauch in psychology, along with France. Thomas Reid, a common sense rationalist, was at work in Scotland before the century opened. By 1803 Thomas Brown had begun to publish. While unable to abandon associationism, (psychological atomism) he radically redefined it, in terms of "suggestion," a concept logically similar to *conservation* in physical science and *transformation* in mathematics. The year before, Maine de Biran had complained that associationism made the organism *mentally passive.* He turned, therefore, toward voluntarism, and the self as an energetic unity acting upon sense impressions, a position that had characterized the psychology of Leibnitz in the earlier pre-organismic days, and to which modern psychology is returning.

One of the outstanding psychologists of this period was Johann Friedrich Herbart who employed apperception as a means of explaining mental unity, keeping association by means of which to satisfy problems of plurality. His object was to define the part as operative *within the whole*, that is, to postulate a real plurality *within a real unity*, a truly organic unity, which formalism in psychology, here-to-fore, had failed to accomplish. The whole had always been, vitalistically, outside the parts. It had been a *deux ex machina.* But Herbart, too, was unsuccessful, for it was not yet the day of the relative-absolute (transposable form).

In 1820 Th. Brown suggested his famous laws of mental processes, whereby the so-called primary laws of association—contiguity, repetition, cause and effect—were subordinated to "constitutional differences" and "emotional congruity," a clear recognition of the primacy of the mind-as-a-whole. There was also Friedrich Edward Beneke, who emphasized the "interworking of

elementary mental data," the precise analogue of similar ideas advanced by Sir Charles Bell, Prochaska, Magendie and others in physiology. Flourens, and Legallais, by extirpation techniques, *had found that the brain functions as a whole.* These two men were forgotten, or denied, for one hundred years. Instead, neuropsychology followed the lead of the atomistic phrenologists, Gall and Spurzheim! Even today the concept of "localization of function" is deep rooted in biology, psychology and medicine, in spite of the fact that all the recent work confirms Flourens who, almost alone, fought phrenology with insight.

Social science is no exception to the rule. Medicine is becoming more socially minded. There was Philippe Pinel who worked for hospital reform, and saw psychiatry as partly a social problem. There was corresponding work in connection with the feeble-minded and the blind. Social theory turned to organicism, and back to Campanella and Grotius. Adam Müller, Count de St. Simon, Robert Owen, August Comte, De Tocqueville, Mazzini, Proudhon, and of course, Hegel, all crowd into this short thirty years with organismic, dynamic conceptions. The part is relative to (subordinate to) the whole, but naturally derives its freedom from it. These were days of attempted social reform, efforts to stem the confusion of a socially and economically mechanistic system, laid down on the false principles of unregulated laissez-faire and rugged individualism. Utilitarian ethics universally gives way to idealism. Rights are defined as duties, not as innate (inborn) properties that need not be earned. Competition theories of social progress are supplanted by cooperation theories and many cooperative enterprises are started, most of which were failures, only because man was not ready to accept them. Much interest is shown in the philosophy of law. From what source do law and loyalty derive their sanction and purpose? The source must be a reality. It was the state, a socially over-summative whole. It matters not that social science, psychology and biology of necessity turned to vitalism in order to solve the part-whole problem. This was 1820. Vitalistic thinking, however, was nearer the truth than the mechanistic.

Philosophy returned to rationalism, idealism and formalism.

We have mentioned Kant and Fichte. There were also Schelling, and the famous Hegel, Thomas Reid, Thomas Brown, Dugald Stewart, de Maistre, Maine de Biran, C. G. Carus, and Victor Cousin. While they differed in many respects from one another, none of them forsook the fundamental problem, that of the primacy of the whole. All were unalterably opposed to the theory that experience is exclusively built up piece-meal and that the mind is a blank at birth. None would repeat the errors of John Locke and David Hume if he could prevent it.

But the most tangible evidence of our thesis comes from the "Queen of the Sciences," mathematics. The very year that the century opens, Geometry returns (G. Monge). Its reception was slow, but in 1810 came J. D. Gergonne, and in the 1820's Poncelet, Couchy, and Abel. It was during this decade that J. Bolyai and Lobachevski had thought out their non-Euclidean, relativistic systems. We have already mentioned Gauss's relativistic leanings. Poncelet showed how the properties of figures held when the figures were varied according to definite laws (transformation), also how they held their properties when *limiting positions* were assumed. (Boundary and limit problems were characteristic of this period and interest in them survived throughout the century.) It was in this period that Sir William R. Hamilton made his initial contributions, although abandonment of the absolutistic, mechanistic and atomistic commutative law, which enabled him to discover quaternions, did not come until organismic thought, save in mathematics, had almost died. In 1831, Joseph Plücker launched his analytic attack upon Geometry which so few at the time understood. Legendres' earlier work on theories of numbers, geodesics, and *least squares* should be mentioned. In 1830 came Galois, and in 1832, Jakob Steiner, who, perhaps, more than any other two mathematicians, epitomized the insight of the age. From what source came the possibility of transformations, the regulation and repetition of pattern and form, the co-variance of mathematical laws? In three short years, Galois saw deeper into these problems than mathematicians were to see for many decades. A *group* stands behind the possibility of transformation. The special case derives its properties, validity, and possibility of solution from the whole of which it is a part.

Now note the wording that Jakob Steiner gave to the title of his geometry: *Systematische Entwicklung Abhängigkeit geometrischen Gestalten von einander.* Gestalten!, a word that Goethe employed to mean static organic form in animals, and that Fichte had used in referring to the state, with almost precisely the same logical connotation. About fifteen years ago the term returned by way of psychology and was soon in use in biology and physics *but the idea preceded the* word both in biology and in physics. In returning, the concept was shorn of its former vitalistic meaning.

Steiner found a mathematical "organism," a larger unity or whole, that ordered a vast array of diverse phenomena. He was discovering *the laws of the generation of mathematical forms.* Another fundamental conception of Steiner was the theory that mathematical terms *were subordinate to the relations that united them.* The way was being paved for a true relativity. It is not long before points, quantities, and other atomistic concepts of mathematics are to vanish as primary data. We must not forget Dirichlet's interest in the minimum principle, the early work on vectors (Hamilton), and the later work by Grassmann, or the reasoning of de Morgan, or the Riemann who was coming.

Unlike most of the other sciences, mathematics failed, on the whole, to decline in its theoretical contributions down through the century although the twenty years, 1855 to 1875, were dull. Controversies and astonishments followed in quick succession. Sturm, von Staudt, Riemann, Cayley, Sylvester, Boole, Kummer, Kronecker, Weierstrass, Clifford, Lie, Klein, Cantor, Dedekind, Peano, Hilbert, Minkowski, and many others supply almost a steady stream of contributors who are constantly making mathematics more and more a "*qualitative*" science of form, position, order, invariance, transformation, pattern and classes, in short, of part-whole relations, of variance within invariance, rather than an atomistic science of number, infinitesimals, points, and quantities. *Mathematics has led science in the process of becoming organic, or better, organismic, and "qualitative."*

Turning to the opposite end of the scientific range, social science presents a similar picture. Individualism, laissez-faire, contract theories, and utilitarianism, died for good in the eight-

eenth century, *so far as well informed scholarship is concerned*, save for John Stuart Mill, who was followed by the practical world. (Mill changed toward socialism in his later years as did Rousseau.) Yet a long line of toilers made very little impression on society except to promote state loyalty in Germany, and here it was because the political scientists were in close touch with the Kaiser. The culture pattern had swung to the other extreme again, toward atomism and individualism.

The world was not ready for higher unities. There could be no lasting unity under a laissez-faire system which opposes coördination, but on the other hand there could be no lasting unity under class dominance, either of the priesthood, the nobility, the army, or the capitalist.

In philosophy, psychology, chemistry, physics, and generally in biology, atomism, materialism, and elementarism were to have another round, along with rugged individualism, war, exploitation, imperialism, expansion and material construction, a period of universal insurrection and a broadening of the franchise. The swing was rapid, pushed by the "industrial revolution." The fruits of 1800 to 1840 were to be applied and assimilated, with human nature still uncivilized, selfish, and woefully atomistic. The period from 1840 to 1900 (perhaps 1915) is not to be condemned, but its scientific and philosophical thought outside of the exceptions just mentioned was relatively barren, not only barren, but complacent. Atomism struck chemistry with a fever from which that science has not yet recovered in spite of Butlerow, Pasteur, and Ostwald. In biology, Darwin typifies the absurdities of atomism. But Darwin was a symptom, not a cause, and it is little realized, even today, that he distrusted his own theory, especially its social application.

Psychology and philosophy were in a state of utter confusion through the century. Psychology was revived and given an experimental basis by Wundt, Fechner and Stumpf. Rationalism returned through two channels, partly through Wundt, and partly through Brentano. Sir Wm. Hamilton, the Scottish philosopher, then Green and finally Caird and Bradley, kept the formal approach alive in Great Britain, to reveal itself in the British cona-

tion psychology of 1900, in opposition to the associationism of Alexander Bain.

But on the whole materialism and mechanism raged through the 50's, 60's and 70's—Waitz, Renouvier, Büchner, Bain, Lazarus, Czolbe, K. Vogt, and Moleschotte, to be reflected in an empty mental chemistry, in the later psychological structuralisms of Wundt, Külpe, and Titchener, in the James-Lange theory of emotion, and in the atavistic bond psychology and conditioned reflex movement of the early 1900's. These were not *all* futile, but the theory they represented was sterile machinism, the thought of 1400, 1775 and 1860.

The nineties, however, deserve special mention. Wundt tried to superimpose upon his atomism in psychology the principle of *creative synthesis*. In psychology, generally, there was a feeling that associationism was wrong but no one knew how to correct it. Wm. James made a heroic effort. James Ward tried to abandon it. G. H. Lewes made brilliant suggestions looking toward an organismic position. Ehrenfels, Cornelius, and O. Meinong were speaking of Gestaltqualitäten, and *funded* or *connected* contents. G. E. Müller tried to make attention solve the problem of unity. Titchener was facing the same problem but with an impossible set of inferences. All through this period the desire to make psychology experimental and inductive prevented psychologists from an adequate conception of experimental problems, which requires deduction.

During the same period, W. Roux was urging a science of developmental mechanics in biology, based upon a conception of the organism as a whole. Bütschli and Boveri were reviving interest in the dynamics of protoplasm, a problem tracing back to Borelli and Galileo. Sedgwick, Wilson and Whitman were pounding away at the cell theory while Mach, Ostwald and Stallo were opposing atomism in physical science. Claude Bernard had already, and almost alone, sustained an organismic position in biology. Semon was initiating a line of thought that in essence was correct, although at first awkwardly expressed, in his concept of the *mneme*, and the *organizer*, which modern biology, in the work of Child and others, is reducing to the dynamics of physio-

logical fields, structured gradient-wise. All this is an emphasis upon *form*.

We have now reached 1900. The culture-pattern, as it is represented at the level of scholarship, will shortly burst into a new enlightenment along the lines crudely but magnificently laid down in 1820. Again there will be an emphasis upon the part-whole problem, geometry, invariance and co-variance, transformation and transposition, maxima and minima, conservation, form (Gestalt), teleology, final causes, rationalism and idealism, deduction, socialism, organicism, all of which belong to a single, unified thought-pattern, all based upon a single family of implied postulates, and all contrary to the assumptions upon which atomism, mechanism, elementarism, hedonism, utilitarianism, and romanticism are based.

II. 1900–1935

The first return of the organismic pattern is the re-discovery of *continuity*. By 1900 mathematics had already made the discovery. Continuity is not composed of parts; it is an *original whole*. In other sciences, the transition takes place by way of discovering a new type of element (atomism is still persisting), an element of *action*. Psychology was trying to think of function and structure as a single unit. Contents of consciousness were discovered that were also *acts*, and in the same connection, the *Gestaltqualität* was discovered but defined as a *form element*. This movement in psychology was an effort to see continuity and unity. It is interesting that introspection and measurement, respectively, in two widely different fields, should be demanding the same type of re-organization in thought. However, this is no mystery if our thesis is correct, that the scientific mind has always employed the same thought-pattern.

What did chemistry mean when it created concepts of valence and affinity, if not for the purpose of solving a problem in *belongingness*, or continuity between things? Why did biology seize upon the concepts of adaptation and evolution and turn to the problem of growth? Why did William James speak of the stream of consciousness? Why did many biologists try to explain hered-

ity and growth by means of organic memory? Why did Freud revive the concept of the subconscious? Why did Ribot speak of dynamogenesis, the flowing of thought into action; or Fouillée of force-ideas, or Lipps of striving, or Stout and McDougall of conation? Why did social science turn to the problem of the assimilation of one culture *into* another? Why do we find developing a new philosophy of history? Why is the antiquity of man studied with avidity? The scientific mind is turning toward unity, through the intermediate step of continuity, and, in so doing, it has discovered the problem of *direction* (mathematics had already become interested in *vector* phenomena).

Why did mechanism collapse? For the simple reason that it was utterly helpless in face of continuity, direction and unity. Experimental work, before 1900, was demanding a new vision, a modernized conception of society and the State were being demanded in social science; and the evils of rugged individualism were already being aired.

Our procedure will now be that of inspecting numerous individual pieces of a vast jig-saw puzzle, in an effort to find the pattern of the picture, only, it is a pattern in which each part epitomizes the whole (Conger, 1931). In other words our object is to make an inductive study of the growth of the field-concept.

Around 1902, in biology, C. M. Child began his studies of regulation, out of which came the concept of the physiological field-property, structured gradient-wise, to which the parts of the organism are subordinate, yet to which they contribute. 1902 was to see *La science et l'hypotheses*, by Henri Poincaré, who, more clearly than any other scientist in this decade, saw the problem of the part-whole relation.

In 1903 Alfred Binet strongly protested against mechanistic, association psychology. A formative force, he insisted, operates in the individual and in the physical world, molding the form of beings and guiding their evolution. How reminiscent this is, not only of 1820, but also of 1650! The concept of *intra-organic* energy is being urged by Gustave le Bon, known not only in physics but also in social psychology. Jennings is opposing the "mechanism" of Jacques Loeb; Henri Pièron is suggesting that

the laws of a system are necessary to supplement mechanistic association concepts in psychology.

In 1905, G. H. Darwin compares the history of a star with that of an individual animal. That is, life and matter follow the same set of universal laws. Max Weber had, the year before, contended that science (as it was then) was incapable of investigating wholes, and promoted a method by which social phenomena were to be investigated in their totalities. Bernard Bosanquet was frankly raising the problem of teleology. Conradi found that English sparrows, raised by canaries, sang like canaries. Wilhelm Ostwald published his *Vorlesungen über Naturphilosophie* which was a vigorous stand against "atomism" and "machinism." William McDougall wrote a physiological psychology, and commenced a life-long battle, yet unfinished, for a scientific treatment of teleology and purpose. Last, but by no means least, this year brought the publication of Einstein's restricted theory of relativity, which lead to the discovery of physical parts, transposable within a physical whole.

The forward march continues in 1906. J. Mark Baldwin wrote *Mental Development in the Child and the Race*, followed in 1911 by *The Individual in Society*. Here, beginnings were laid for the idea that the human mind differentiates only in the presence of a social *milieu*. A similar view was expressed, in the same decade, by Cooley and by Draghicesco, in sociology.

Le Dantec seems to be little known in biological theory. In 1908 he raised the problem of individuality (oneness) in organisms. They must be considered as a whole, but how? They are physically and chemically constituted. How in these terms is individuality to be comprehended in a scientific fashion? A solution seems to lie in the Le Chatelier theorem (1888). His is a brilliant suggestion, since made many times in the biological literature, and, in 1926, used with telling effectiveness by William A. White in *The Meaning of Disease*. Indeed, this principle when expanded and generalized, is one of the great discoveries of modern times. Perhaps more than any other single idea, it shows how a whole can change and yet not change; how growth and exchange of

energy with environment can occur in the living organism and yet not destroy its identity and continuity.

Let us skip to 1909, when W. M. Urban contends that the value of the whole is more than the sums of values of its parts. Keith Lucas discovers the all-or-none contraction of skeletal muscle, an important step in the varied types of experimental evidence that were to promote a further return to problems of wholeness and unity. Later, the same principle was found to hold for the nerve fiber.

In the same year, Abbot Thayer, studying concealing coloration in the animal kingdom, noticed that the animal must be considered as a whole, and not as an aggregate of chemical processes, if this problem were to be solved. Concurrently, Voronoff was working on the dynamics of social wholes. C. H. Cooley, who had published as early as 1902, adumbrated an organismic conception of society. Human nature does not develop in isolation; it is derived from a social *milieu*.

We must mention Leduc, who, in 1910, published his *Theorie physico-chimique de la vie*. Forms resembling plant and animal life were produced by employing the principles of osmosis, diffusion, capillary attraction, surface tension, and the like. The resemblance of purely chemical growths to plants and cells was astonishing. Indeed, he succeeded in simulating not only growth, but also respiration and reproduction.

In 1911, Jennings challenges the fatalism that inevitably resulted from the Weismannian conception of heredity (preformation). Rutherford refuted for all time the theory of the solid atom. The atom is a system, and largely devoid of matter. Meanwhile, chemistry was discovering interesting phenomena. Reactions based on water as a solvent transpose to other solvents (Franklin *et al.*). This is the same type of discovery that helped to produce a revolution in psychology. It means, for chemistry, that relativistic and configurational definitions must be given of the acid, base and salt. The acid is not an acid because of its hydrogen ion, but because of its relation to the solvent. An animal, trained to feed from a pattern of lights of the relative brightness 45, 30 and 15, and punished for going to the 45 and 30,

because the 15 is the light selected by the experimenter as the goal, will, when the lights are stepped up to 75, 60 and 45, choose the 45 with no hesitation (after Köhler).

It was in 1912 that Wertheimer's experiment on apparent movement proved that this illusion must be explained by assuming a response of the optic system as a whole. There was no correspondence between the mode of stimulation and the seen result. Mosaic theories of retinal functioning, therefore, were out of the question. *Gestalt* theory traces its immediate history from this experiment. It is interesting to note that the years 1911, 1912 and 1913 are especially important in all of the sciences. The revolution is coming simultaneously, or very nearly so.

In 1913, Percival Lowell spoke of the solar system as an inorganic organism. Simultaneously, A. J. Herbertson said that the forest was more than the sum of its trees, and E. V. Huntington expressed much the same point of view in unifying a set of postulates for abstract geometry by means of the single relation of inclusion. Lawrence J. Henderson, in *The Fitness of Environment*, boldly advocates a unified conception of the organism and its environment. The one is adapted to the other, mutually. The world, with its forms of life, is evolving as a single whole, with all of its parts or phases already integrated as they evolve, in a genuinely teleological system. Harry C. Jones, a follower of Ostwald, wrote *A New Era in Chemistry*, one of the few books in this science to reflect the growing interest in a more rational and organic approach. Paul Walden's *Salts, Acids and Bases*, 1928, is another.

In 1914 C. R. Darling noted a resemblance between chemical and vital processes in a paper, "Inorganic Feeding." In 1915, C. M. Child publishes under the significant titles, *A Dynamic Conception of the Organic Individual*, and *Individuality in Organisms*. Le Ferriere presents an organismic view of society; R. E. Lloyd could see no difference between human and non-human purpose, and Marina finds that the theory of localization of function of the cortex is inadequate. In other words, the cortex functions as a whole. Pareto publishes his famous work on sociology, a definite approach to a social dynamics and to *Gestalt* con-

cepts. Schaxel is taking an important place in the development of theoretical biology along organismic lines. Again, last but not least, is Einstein's generalized theory of relativity, which, in a sweeping revolution, made the part transposable across the whole. Relativity and unity are one.

In 1916 Freud, who had already developed a dynamic conception of the personality, now improves upon his theory by assuming a more social approach. The personality individuates from a social pattern. J. E. Boodin, in the same year, gives us one of the best accounts, up to now, of the logic of the part-whole problem, in *A Realistic Universe*. G. N. Lewis sees a part-whole problem that has not been solved in chemistry, in connection with the atom, and implicitly assumes that the whole controls its parts.

Also, in 1916, E. S. Russell wrote *Form and Function*. This book traces the history of biology from the standpoint of the organism as a whole, and accepts an organismic and teleological position. Another important book appeared in 1916, *Creative Intelligence*, by John Dewey, Boyd H. Bode, *et al.* Here, Bode points out that consciousness connects the organism with its future; mind is the future, operative in the present.

In 1917 Lawrence J. Henderson's *The Order of Nature*, appeared, in which difficulties with the part-whole problem are traced historically. There is a determined stand for teleology by the author who, afterward, so successfully applied the nomographic method of ordering masses of complex data relating to organic problems.

During this period Kappers is working with the principle of neurobiotaxis, a dynamic conception of the growth of nerve cells and fibers with respect to local fields. Kjellen advocates an organic conception of the State; Laski is demanding a new conception of the State. The old problems of authority and sanction are raised again. Millard discusses the cycles of history from a dynamic point of view; Szymanski interprets animal behavior in terms of least action; F. J. E. Woodbridge sees that structure is taking the place of substance; and D'Arcy W. Thompson publishes his *Growth and Form*. Here the form and growth of plant and animal life are studied from the standpoint of the dynamics of form—the principles of least action, space partitioning under

the law of minimum areas, the development of segments, membranes and skeleton under the law of similitude, the problem of logarithmic spirals so common in nature, the problems of symmetry, osmosis, absorption, and the possible variation of species in accordance with the systematic variation of coordinate systems.

We find ourselves in 1918. Typical of the enlightenment in general is Deshumbert's *An Ethical System Based on the Laws of Nature.* Hobhouse is presenting an organismic theory of the State, attempting to correct vitalistic errors in a similar theory previously suggested by Bernard Bosanquet. A. L. Kroeber regards society as a supersummative system.

By now, philosophers are recognizing the definite return of rationalism which, in the past, had been pre-organismic. Botany has a vigorous exponent of the organismic point of view in Ungerer, and W. E. Ritter publishes an outstanding treatise on *The Unity of the Organism.*

In 1919 came an edition of Bechhold's *Colloids in Biology and Medicine.* It must have taken courage to say that colloids exhibit curves of life, the phenomena of individuality and of 'death,' meaning by these expressions more than figures of speech. Later, Armstrong was to say that colloids acted "as if" they were intelligent, that is, in their marked selectivity of action. Harlow Shapley, in discussing the structure of the universe was finding the phenomenon of regulation, as biologists were finding it in living organisms. W. E. Ritter expounds *An Organismal Theory of Consciousness*; H. H. Bawden is finding in the evolution of behavior, a forward reference, a conception which Herrick and Coghill were later to find necessary if ontogeny is to be understood.

In 1920 there appeared another excellent description of the part-whole problem, from a logical point of view, this time by Bernard Bosanquet. There was also a profound discussion of methodology, in physics, by Norman R. Campbell. In the latter book, the fallacies of mechanism, as found in methodology, receive convincing criticism, such as the view that science is an inductive discipline, primarily, and that laws depend upon measurement. On the contrary, the conception of a scientific

law is necessary both in order to set up the experiment and in order to construct the instruments of measurement. Then the instruments are employed by means of which to test the law and to refine its expression.

In the same year, 1920, appeared Köhler's work on physical *Gestalten*. Köhler, primarily a psychologist, sees that the physical sciences face the problem of *Gestalt*, and gives numerous examples of the transposability of physical wholes. Notice, now, how consciousness of system or plan is returning: W. Patten discusses *The Grand Strategy of Evolution*, saying that a solar system as a whole is more than the sum of its parts and has a creative power of its own. In the same year Arvid Reuterdahl insists that understanding physical problems requires the supposition of an activity principle. This reminds us of Kepler's *facultas formatrix*. R. H. Wheeler finds that the psychology of that decade is useless in explaining volitional activity. There is no criterion of volition other than volition itself, and the behavior of the organism as a whole is involved. In choosing, the muscular system is as necessary as the brain. A. N. Whitehead, one of the most scholarly and consistent advocates of an organic view of nature, published *The Concept of Nature* in 1920. His organic view is based upon mathematical and physical considerations. The key to his position may be found in such expressions as "electromagnetic society" and "organic mechanism."

The year 1921 brings a host of new names, adherents to the organic view of nature, to the universality of laws, and to the problem of the many in the one. W. Bechtereff writes his *Collective Reflexology*, a system of social energetics based upon the laws of dynamics. David Burn's, *An Introduction to Bio-physics*, says the principle of least action applies to psychological, economic and ethical systems. Bragg is emphasizing wholes, also. At this time E. J. Carey is writing on the dynamics of histogenesis; C. M. Child is explaining the development of the nervous system by means of dynamic, physiological gradients which are field-properties of the organism as a whole. Kurt Koffka is now applying Gestalt psychology to problems in mental development and is vigorously attacking mechanistic, bond, association psy-

chology. Before this time J. S. Mill and S. Alexander had adumbrated the concept of emergent evolution which was advanced in detailed form by C. L. Morgan.

In 1923 Püffer is calling the cell a Gestalt. J. W. N. Sullivan is interpreting science teleologically. For some time it had been realized that defining terms, in the equations of physical science, as if the factors involved were passive or static, was an inadequate procedure.

In the same year George Humphry draws a parallel between *Gestalt* psychology and relativistic physics. K. S. Lashley attacks the mechanistic and atomistic theory that synaptic resistance is reduced by the passage of the nerve impulse.

R. M. MacIver is defining society as a spiritual unity. N. L. Sims publishes *Society and Its Surplus*, interpreting social and economic phenomena in terms of the dynamics of social structures. R. H. Wheeler points out that freedom and determinism constitute a natural, logical whole. Instead of being contrary to one another, they define one another. We are now in the period during which wave mechanics is being developed, to culminate, for the purposes of this discussion, in the use of the term *Gestalt* by Erwin Schroedinger in 1929.

We still have twelve years to go, while the literature is becoming richer in organismic content. In 1922 Gurwitch discusses in detail a field-hypothesis for biology. Edward Price insists that differences in form are basic to diversity of character among chemical 'substances.' In short, there are no chemical substances; there are chemical *Gestalten*. R. Magnus shows that reflexes are not fixed elements of motility, as had been supposed, but are different for different postures of the animal.

L. Rougier, in his *Philosophy and the New Physics*, points out the resemblance of modern thought to that of Faraday who localized energy not in substance, things and entities (innate properties) but in the dialectric medium, that is, in the whole, not its parts. David Russell remarks that continuity is of a higher order of reality than the microscopic or molecular. Louis Stromeyer bases a theory of the universe on the concept of intersistence. C. S. Sherrington sees the necessity of interpret-

ing reflexes as factors secondary to the integration of the nervous system as a whole. W. T. Astbury tells us that, in crystals, when the pattern as a whole is symmetrical, fewer molecules are required. The form of the crystal obeys a law of least number, and a law of rational indices, concerned with the relation of the symmetry of the parts to the symmetry of the whole.

Special mention should be made of C. E. Guye's *Physico-chemical Evolution.* Here the daring suggestion is made that physics would find assistance, in solving its own problems, by turning to more general problems, even to biology and psychology. In short, the less exact, do not refer to the more exact, sciences, for basic principles. In this sense no science is basic to any other. The same *ideas* belong to all the sciences, but the less exact turn to the more exact sciences for methods of control.

E. Kretschmer's *Physique and Character* (Tr.) appears in 1925. This book typifies a vast literature in characterology or typology, another case of modern "holism." The personality and physical configuration of the individual are studied as a single whole with marked success relative to two outstanding physical-mental types, the aesthenic, whose abnormal form is schizzophrenia, and the pyknic, whose abnormal form is the manic-depressive.

Alfred J. Lotka publishes his *Elements of Physical Biology* in 1925. Here, evolution and ecology are treated dynamically with a precision that is most encouraging for biological science. Among the many interesting suggestions is his treatment of the problem of "causation from the future." Teleology has definitely returned. In approaching equilibrium, teleology finds a rigorous scientific definition.

In this year Whitehead follows his other organismic writings with *The Principles of Natural Knowledge.* C. H. D. Clark explains that electrons and protons possess an *individuality* that is maintained by interaction.

From now on a history of organismic developments might be written merely in terms of book titles. One of the best of these books was written by a soldier and a man of public life, who has found time to be an admirable scientist, as well, General Jan C. Smuts. [P. W. Bridgman is reflecting a strong movement in

modern thought, and one which is proving most fruitful, namely, operationalism, an analogue of instrumentalism and emergence.]

Again the origin of species is seen as a problem of a larger whole; and the logic of system receives a thorough discussion, in Paul Weiss's *Morphodynamik*. William Morton Wheeler, entomologist, accepts emergent evolution and a configurational position, followed in 1928 by his *Emergent Evolution and the Development of Societies*, in which symbiosis, insect and human societies are defined from a dynamic point of view as over-summative wholes or Gestalten.

It is being discovered that genes are not absolute entities with fixed, endowed properties, indeed, the question is raised whether or not they exist at all.

Harry Helson investigates insight in the white rat and interprets it in terms of least action. Only a few years previously, intelligence was denied the rat under a false interpretation of the law of parsimony. K. C. Hsiao is attacking mechanistic conceptions of the State (pluralism) and suggests that monism must be modernized to include the problem of pluralism. The same year brought G. N. Lewis's *The Anatomy of Science*, in which is discussed his principle of virtual contact, a variety of the conditioning of the present by the future. C. L. Morgan considers physical as well as biological systems as Gestalten. Michel Pupin tells us that "creative coördination" is the message of physical science to humanity, and that science, religion and art are inseparable parts of a single science. Oliver Reiser, who has been writing many articles, developing an organismic postion, applies least action and the principle of maximum work, the latter borrowed from chemistry, to organic and psychological problems. Clark Wissler discusses a field-theory for cultural anthropology.

In 1928, there appeared Ludwig von Bertalanffy's *Kritische Theorie der Formbildung*, adapted and translated in 1933 by J. E. Woodger, under the title, *Modern Theories of Development*. Here the organismic view, and a field theory, are stoutly defended, even to the position that a scientific teleology is indispensable. N. O. Lossky's book, *The World as an Organic Whole* is another penetrating analysis of the part-whole logic, but in the end is

dominated by a vistalistic position. Mrs. Frances Mason edits a book, *Creation by Evolution*, to be followed by another in 1934 *The Great Design*. The modern conviction of scientists in the existence of a universe which has a plan is no vitalistic mania, nor an unwarranted return to the past.

During the year 1927 Shereshefsky points out that the classical theory of cohesion is wrong. What is needed is a mathematical instrument by means of which to handle cohesion as a field-property, the property of form, not of an aggregate of particles each with its independent and separate force. Similarly, J. S. Haldane, in an important book on *Liquids and Gases*, finds that van't Hoff's equations for osmosis will not adequately predict the facts. The reason is that saturation has been defined as a passive, rather than an active factor in the equations.

In 1929, G. E. Coghill publishes an epoch making work in neurology, already mentioned, *Anatomy and the Problem of Behavior*, in which he finds indisputable evidence that the embryo (salamander), as soon as the muscle segments can be innervated by the central nervous system, responds as a single piece, and that 'local' movements, so-called, even to reflexes, are not local movements but are differentiations of a mass action that is at first overt, and then reduces to posture. The whole is primary. In 1929 Einstein publishes his unified field theory of the universe. Whether this magnificent attempt is entirely satisfactory or not, for the time being, is a secondary matter so far as the destiny of the field-concept in general is concerned.

The macroscopic-microscopic problem is again discussed, in chemistry, by W. A. Waters. Chemistry had already found it necessary to invent expressions depicting a movement away from absolutism, elementarism and atomism toward relativity, and dynamic field-concepts dealing with part-whole patterns. The benzene ring system, for example, can transmit intramolecular movements of electrons from atom to atom without alteration of intrinsic structural form; and directing substituent groups guide extra, free energy to selected positions of attack. Groups preserve similar relative activating powers under widely reaction conditions. Can one doubt that chemistry, too, faces the

problems of self-regulation and Gestalt? Finally, in 1929, J. H. Woodger publishes an important book, *Biological Principles*. The position is organismic throughout.

Following the work of Koffka, Miss Andrews found that young children, two and one-half years of age, could identify the parts of a face (picture) so long as they were parts of a face, but when identically the same part was isolated, on a separate card, it was no longer perceived as part of a face, but as a whole in its own right. The nose was a tent or a mountain; the ear a coil of rope; the eye a bird's nest; the mouth a stairway.

In 1930, also, W. M. Borovski finds that the learning process obeys a minimum law. F. O. Bower publishes a splendid study, *Size and Form in Plants*, demonstrating minimum laws and the law of similitude in the growth of primitive plants. In the same year C. M. Case is applying the Gestalt concept to sociology. Tobias Dantzig publishes an interesting, non-technical history of mathematics, *Number, the Language of Science*, pointing out the basic, organic character of the 'mother of the sciences.' Dantzig (Wertheimer also) mentions that primitive man at first apprehends number groups as wholes, non-additively. That is, pairs, triplets, quartets, etc., are perceived as units, so that words like pair, duet, brace, flock, herd, and the like, are older than 1, 2, 3, and 4. Again, wholes are primary. J. A. Gengerelli interprets animal learning in terms of maxima and minima. O. C. Irwin, following Pratt, Weiss *et al.*, finds that the motility of the newborn infant follows the 'Coghill cycle' from mass action to individuated action. The whole is primary. Sir James Jeans writes *The Mysterious Universe*, taking the point of view throughout that the universe resembles a single logical system, as if the "Creator" were a mathematician and geometrician. Dominated by relativistic and organismic conceptions H. S. Jennings publishes an important book in biology, *The Biological Basis of Human Nature*. W. B. Lee discusses adhesion phenomena. A field-concept is necessary, here, to render the results of experiment intelligible. Forces of the whole are more than the separate forces of the parts, that is, *the action of forces between atoms, ions and molecules, acting together, constitute fundamental attributes of matter.*

In 1931, E. T. Bell's *Queen of the Sciences* appears. There could be no better evidence, from the standpoint of a layman, that mathematics is an organic science, dealing with mathematical *Gestalten*. Operations of higher mathematics resemble the functioning of an army that is obeying a single order. In the same year the over-summative character of systems in nature is again emphasized, this time by Morris R. Cohen, in his *Reason and Nature*.

One of the most complete efforts, in the literature, to effect a unification of scientific data, is George Perrigo Conger's *A World of Epitomizations*. Here several organismic postulates are developed with reference to astronomy, physics, chemistry, biology, psychology, social science, mathematics and logic. There is universality of law; the part epitomizes the whole; systems are over-summative wholes. Sir Arthur Eddington discusses cosmic *versus* local time in relation to the theory of wave tensors. Cosmic time, the public time of wholes is a transposable *Gestalt*. In this paper we find one of the few references to the kernel of the twentieth century revolution in science. The naïve mind reverses the order of nature. It sees the parts first and erroneously tries to build up the whole from them. According to R. H. Wheeler this reversal takes place both at the observational and intellectual levels, and most persons never learn to correct the error, because of a deficient educational system based on classical science. Atomism (the parts come first) at the intellectual level is the same as selfishness at the feeling level. The latter cannot be corrected unless the entire thought-pattern of the individual is reversed.

In F. S. C. Northrop's *Science and First Principles*, the relation of relativity to unity, the dynamics of the many in the one, are discussed in vivid detail in the fields of physics and biology, even in ethics. There are two sources of energy, the parts and the whole, which are in conflict. The macroscopic atom impresses itself upon the microscopic parts, stabilizing an otherwise chaotic field of motions.

In the same year, 1931, appeared Wheeler's *Laws of Human Nature* a small book in which eight laws of dynamics are employed for the purpose of unifying the facts of perception, learning, feel-

ing, personality and social psychology, and also in order to relate the facts of psychology with those of physics and biology. Wheeler and Bertalanffy agree that vitalism is a special case of mechanistic thinking, an effort to avoid mechanism with nothing but a mechanistic pattern with which to work.

Organismic logic finds a striking exponent in Bernard Dürken's *Experimental Analysis of Development*, translated in 1932. It is pointed out that the statistical method in genetics is justified by its results, but is an unsound basis upon which to rest a theory of heredity. The germ cell as a whole is the "transformation unit," to which the chromosomes are relative and subordinate. Ritter, in 1919, had insisted that heredity should not be regarded as transmission, but as transformation or transposition of a total, organic pattern. R. H. Wheeler suggests that a biological process, once started, proceeds in the same direction unless checked or modified by enviornment.

F. A. Lindemann regards the quantum as the product of an error, the error of measuring one coördinate in the conjugate coördinate. Independently R. H. Wheeler concludes that the quantum is the product of an error. Quanta, according to him, constitute a discontinuum resulting from the interaction of two systems of energy having different degrees of structural differentiation. Assume that a more finely structured system is impinging upon a more grossly structured one. The grosser structure possesses thresholds with respect to the finer, and waits, before responding *overtly*, until certain maxima (quanta) have acted. Then the response divides or structures the impinging system into quanta, which may or may not actually exist in the impinging system. In this way a measuring device, cruder than the energy it is measuring, *will make quanta out of it.* The human system behaves in the same way toward its environment, frequently seeing (or thinking) things that are only artifacts. Among them are "atoms" (used in a logical sense as independent, isolated parts).

Max Planck's *Where is Science Going*, is another typical book of the day. R. H. Wheeler and F. T. Perkins publish an Educational Psychology in which some fifteen organismic laws are em-

ployed operationally, as ordering instruments, among them least action.

Action current techniques are proving very fruitful in studying the cerebral cortex. S. Howard Bartley and F. T. Perkins are plotting "weather maps" of the dog's cortex as a whole, under a variety of repeated stimulus-conditions, and find that in all situations the cortex functions as a single, fluid, dynamic field. Robert L. Brigden had similar success in predicting helicoid, logarithmic and sigmoid spiral movements in man (walking blindfolded in open fields).

An important study can be found in W. B. Cannon's *Wisdom of the Body*. Note the title. Thirty years ago, if a scientist had talked about plan, system, design, wisdom, intelligence, or teleology, in connection with physical phenomena, he would not have been considered a reputable scientist. The key-note to Cannon's study is *homoestasis*, or physiological equilibrium in the organism as a whole. Important also is George Humphrey's *The Nature of Learning*. Learning is a dynamic function of organized energy systems.

Perhaps one of the most astonishing books among the several hundred of the last few years, is Count Alfred Korzybski's *Science and Sanity*. Man is distinguished from the animal as a *time-binder*. Leading on from his earlier work, *The Manhood of Humanity*, Korzybski shows how our language is inadequate to describe the universe we live in. Language is atomistic and absolutistic, while the world is relativistic and holistic. Language emphasizes substance and innate properties while reality is based on form and derived properties. This in itself will account for man's tardiness in overcoming personal maladjustments and social chaos.

The year 1934 reveals an awakening in social science. Sociologists have already attacked the problem of methodology with an interest and rigor quite as scholarly as in the more exact sciences. Douglas W. Campbell suggests that sovereignty is a property that is real and yet relative. Kalecki is studying business cycles from a macrodynamic standpoint. Erich Preiser writes on *Gestalt und Gestaltung der Wirtschaft*, and K. Lewin treats the

behavior of the individual, in his environment, by means of topology. And finally, J. F. Brown has an excellent discussion of the mathematical conceptions underlying the theory of psychological and social fields. Like Lewin, he employs topological concepts and the operational method.

What, then, of the jigsaw puzzle? In all of its vast complexity it is unexpectedly simple. Its simplicity lies in the fact that its laws are, after all, universal; that a simple, stereotyped system obeys the same laws as a complex system with infinitely more variables. The less exact sciences have undergone an enlightenment by employing the laws of dynamics as a logic, operationally, by means of which to refine their definitions and order their data. Physics, chemistry, biology, psychology and social science all face the same types of problems. There is a universal algebra of generalized laws and methods, expressible in words that any scientist, no matter what the field, can understand. These laws reduce the terrific complexities of mathematical physics to transposable *Gestalten* without altering their meaning. The principle of least action, upon which wave-mechanics is based, also various other generalized maximum and minimum laws, laws of form, conservation, transformation, transposition, invariance, co-variance, space partitioning, operational analysis, and topology (non-metricized), have demonstrated their fruitfulness for science as a whole, and it is upon these developments that our present general enlightenment is based. There is coming to light a universal law of over-summative systems, a universal law of part to whole subordination, of individuation, of the dependence of relativity upon unity, a universal law of teleology, of emergent evolution, of participation of the part in the whole under subordination to the whole, the derivation of freedom from this subordination, and many other basic principles. These principles constitute an interrelated logical system which may be called the logic of dynamics, or the logic of form.

The day is here, not only for the more exact sciences to look with favor upon this development, but also to join forces with the psychologist and social scientist in the task which is ahead, the task of social engineering on a scientific basis. From now on, unless civilization is regulated in accordance with these laws, it

will forever be in chaos. Governments must be in the hands of trained scientists, of sound administrative experience, and not in the hands of ignorant politicians, neurotic dictators, and stupid diplomats who have no conception whatever of the laws of social wholes.

It is too late, now, for science to achieve much in this direction during our present enlightenment. Indeed, scientists themselves, just emerging from a mechanistic age in which universal laws, and social planning (based on the scientific discovery of teleology) would have been scorned, are hardly aware of what our present enlightenment means when seen as a whole. Until this discovery is made we can expect the culture cycles, described in the previous section, to continue. These curves predict another wave of insurrection of a universal character, together with international war, to be in full swing within a period of six to fifteen years and to have, perhaps, a maximum duration of about twenty years, *all because man has not discovered the laws of the part-whole system and applied them at the social level.* To employ these laws at the social level will mean man's final emancipation from trial and error living.

Moreover, the cycles will continue until our educational system corrects the atomism of the naïve mind. This will require a complete reorganization of the school system from the kindergarten to the University. The task is a difficult one. The departmental system must be abandoned, and textbooks rewritten. Methods of teaching must be altered, radically, to overcome the atomistic influence of specialized instruction.

The problem strikes deeper, yet, into the heart of human culture. Mechanistic science has rendered man's religion ineffective, if it ever were effective. Now that science has returned to an organismic and teleological position, the unhealthful ethical influence of dualism and agnosticism can be eliminated. A new religion can spring up, to refresh man's insight into the value of life, and it will. Organismic logic transposes across to ethics. Scientific and moral law are one.

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A Note on Parsimony

BY

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IN THIS paper I wish to offer a suggestion in support of the thesis that if a given set of facts is explained by two rival explanations A and B, where A consists of a single hypothesis H_1, and B consists of at least two independent hypotheses H_2 and H_3, then, other things being equal, A is more probable than B. That this view is true is seldom questioned, though I have never seen any reason given for it, which would justify the methodological value so many philosophers attribute to it. It is not my purpose to discuss simplicity of explanation in general, but simply to point out that the Multiplicative Axiom of the calculus of probabilities justifies the above thesis.[1] I shall call this thesis the Principle of Parsimony.[2]

In order to make our discussion as simple as possible, I shall assume that the facts our rival explanations A and B are invented to explain are expressed by the two propositions p and q. We are supposing then that two alternative explanations of these facts are offered: A, which consists of one hypothesis H_1; and B, which is composed of two independent hypothese H_2 and H_3.

[1] J. M. Keynes, in *A Treatise on Probability*, p. 210, states this axiom as follows: $ab/h \cdot = \cdot a/bh \cdot b/h \cdot = \cdot b/ah \cdot a/h$, which may be read this way: The probability that the conjunctive proposition ab is true, relative to evidence h, equals the probability of a on evidence "b and h" multiplied by the probability of b on evidence h, etc.

[2] Cf., William Savery, "Chance and Cosmogony," *Philosophical Review*, March, 1932. This is one of the few attempts to state and justify this principle. I am quite aware that the word "parasimony" is often ambiguously applied to various types of simplicity. It is of course incumbent on those giving it another meaning to define it precisely, and if they attribute methodological significance to it, to validate it.

Though I do not pretend to know the ultimate analysis (if there be any) of propositions entering into hypotheses, I am going to assume that if any hypothesis explains several facts, it is composed of as many propositions. Hence we shall not assume that H_1 has less constituent propositions than have H_2 and H_3 together. So far as I can see it might consist even of more propositions. But whether it have less or more or the same number of propositions is an additional consideration which would have to be considered in comparing particular rival explanations with respect to their probability. The problem I am considering does not depend for its solution upon a determination of this point; therefore, in order to avoid complicating our discussion, I shall assume that the number of propositions composing H_1 equals the number entering into H_2 and H_3 together. Also, for the same reason I shall assume that the antecedent probability of every separate proposition entering into A or B is the same.

Now that our problem is set up, we must explain what we mean by *one* hypothesis. Propositions a and b are constituents of one hypothesis ony if a/bh is greater than a/h.[3] (Since this necessary condition is all we are interested in, we shall leave it to the reader to complete the definition by adding the other necessary conditions.) From this definition, and the fact that any propositions p, q are independent if and only is p/qh equals p/h, it follows that a and b are not independent of each other.[4] Consequently, if a and b were independent they would not be constituents of the same hypothesis.

Accordingly, explanation B is not one hypothesis, for by supposition its constituents H_2 and H_3 are independent, though by our initial supposition explanation A is the one hypothesis H_1. These definitions serve to make clear and precise the nature of our problem, and in fact its solution follows from them and the Multiplicative Axiom; hence, all we need to do now is to explicate our example in terms of them.

[3] In general terms, $p_1, p_2, \ldots . p_n$ are constituents of one hypothesis only if, for every constituent p, there is another constituent or a combination of other constituents q such that p/qh is greater than p/h.

[4] In general terms, p_1 is independent of the set $p_2, p_3, \ldots . p_n$ only if p_1 is independent of every one of these latter ones singly and of every combination of them.

According to our definition of *one* hypothesis, if propositions r and s are parts of H_1, then r/sh is greater than r/h (and consequently s/rh is greater than s/h, though the probability in each case is not necessarily the same). If, on the other hand, r and s were not parts of the same hypothesis, but rather belonged to independent hypotheses, r/sh would not be greater than r/h (and s/rh would not be greater than s/h). This latter situation is true of hypotheses H_2 and H_3, which compose the rival explanation B.

The case before us is this: Our given facts expressed by p and q can be explained by H_1, which is composed of r and s. They can be explained also by the two separate hypotheses H_2 and H_3 taken together, where H_2 consists of proposition t, and H_3 consists of u. Since H_2 and H_3 are *two* hypotheses, t and u are independent; and since H_1 is one hypothesis, r and s are not independent. Let us represent the evidence—*i.e.*, the facts to be explained—by h $(=pq)$. Then the probability of A (or H_1) will be represented by the following equation:

$$rs/h = r/h \cdot s/rh.$$

And the probability of B (or H_2 and H_3 together), by

$$tu/h = t/h \cdot u/th;$$

but since t and u are independent, $u/th = u/h$; hence this latter equation becomes:

$$tu/h = t/h \cdot u/h.$$

In order to compare these two cases let us assume that $r/h = t/h$, and that $s/h = u/h$. Consequently, rs/h is greater than tu/h, for s/rh is greater than u/h.[5] Thus the Principle of Parsimony is proved, subject of course to the specified conditions.[6]

[5] A comparatively simple illustration is found in a circumstantial evidence case in court, in which the prosecution attempts to explain all the facts by an hypothesis connecting them with one individual, the accused, while the defense explains some of the facts by one hypothesis, and other facts by another hypothesis independent of the first.

[6] We may make this conclusion more general by saying that of two rival hypotheses,

That we may make our explanation psychologically more obvious, let us assign arbitrary values to the fractions. Let $r/h = t/h = 1/2$; and let $s/h = u/h = 1/2$. Hence $s/rh = 1/2 + n$, where n is some positive fraction. Then

$$rs/h = (1/2)(1/2 + n) = 1/4 + n/2;$$

and

$$tu/h = (1/2)(1/2) = 1/4.$$

Thus, rs/h is greater than tu/h, and therefore A is more probable than B.

This is, I believe, at least part of the logical foundation of the Principle of Parsimony. If by definition we say that an explanation A is more *parsimonious* than another explanation B if A contains a smaller number of independent hypotheses than does B, then we may formulate the Principle of Parsimony as follows: "Of any set of rival explanations, a more parsimonious one is more probable than a less parsimonious one, provided that all other factors relevant to the probability of the rival explanations are equally favorable to them all." Among these other factors are the antecedent probability of the constituents of each, the probability of each constituent relative to the given evidence and relative to the other constituents of the given hypotheses, and the relative simplicity of the hypotheses themselves. Definition and rules for the evaluation of these factors are important matters in the logic of induction, and are, I believe, far more important than parsimony in any actual case, but to consider them is not part of the objective of this paper. Nor do I think that parsimony is the most important type of simplicity. Number of entities assumed; type, degree, and number of relations or func-

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one will be more probable than the other if the propositions p_1, q_1 of the first, and the propositions p_2, q_2 of the second, are such that p_1/q_1h is greater than p_2/q_2h, other things being equal. This can of course be further generalized for any number of rival hypotheses consisting of any number of propositions.

If no two meaningful hypotheses be completely independent, because of some principle of induction (which is needed to justify all probable judgments), then this general formulation, and not the specific one in the text, would be applicable.

tions; numerical coefficients in quantitative laws; number of terms in polynomial laws; etc., would seem to involve equally if not more important types of simplicity. We have purposed however merely to investigate the very limited proposition that if our evidence be simply the relative parsimony of rival explanations, then the most parsimonious is the most probable.

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Postulational Methods. II

BY

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THE ELEMENTS OF POSTULATE SETS

IN THIS study we shall analyze the postulate set into its various elements. In order to carry out our analysis, it is advisable to have before us a typical set.

We take the set of five postulates for Boolean Algebras given by H. M. Sheffer in Trans. Am. Math Soc. 14, p. 482 ff.

"We assume

i. A class K

ii. A binary K-rule of combination

iii. The following properties of K and /:

1. There are at least two distinct K elements.
2. Whenever a and b are K-elements a/b is a K element.
3. Whenever a and the indicated combinations of a are K-elements $(a')' = a$.
4. Whenever a, b, and the indicated combinations of a and b are K-elements

$$a/(b/b') = a'$$

5. Whenever a, b, c and the indicated combinations of a, b, c are K-elements

$$(a/(b/c))' = (b/c)/(c/a)$$

Definition

$$a' = a/a$$

Classification of Postulates 1–5

Postulate 1 is an existence-postulate. Postulate 2 demands that the K-rule of combination shall be K-closed. Postulate 3 which demands that a and $(a')'$ shall always be names for the same K-element—that the names a and (a')' shall always be equivalent—is an equivalence postulate; so are 4 and 5.

Consistency of Postulates 1–5

With the following interpretation of K and /, postulates 1–5 are satisfied: K has only two distinct elements m and n; $m/n = n$, $m/n = n/m = n/n = m$.

Independence of Postulates 1–5

(We shall only give the proof of the independence of Postulate 5, since it involves the matrix method of consistency.)

With each of the interpretations of K and / given in 1–5 below, all the postulates except the one correspondingly numbered are satisfied; that postulate is therefore independent of the remaining four.

5. K has only three distinct elements l, m, n; / is defined by the following table.

/	l	m	n
l	l	m	n
m	n	n	l
n	m	l	m

Deductions from Postulates 1–5

(We shall reproduce only one of the proofs given.)

A. Whenever a and b are K-elements $a/b = b/a$

Proof. a/b = [(a/b)']' by 3
= [(a/{b'}')']' by 3
= [({b'}'/(a)']' by 5 let b = b', c = b'
= [(b/a)']' by 3
= b/a by 3.

We have selected this set rather than a more mathematical one, because in this form it is easier to note the various elements involved. The axiom sets for the various branches of mathe-

matics (e.g. Geometry by Hilbert, Analysis Situs by R. L. Moore, Projective Geometry by Veblen, Arithmetic by Peano, etc.) are all of the same general form.

The elements of which the above construction is composed are:

a. A set of propositions;
b. A set of assumptions;
c. A set of definitions;
d. An unexpressed method of drawing conclusions;
e. Certain properties as "independence" and "consistency" which are proven of a sub-group of the set of propositions;
f. A set of objects satisfying the construction—which is used to demonstrate consistency.

DEFINITIONS

1. *The entire group of elements enunciated is called the axiom-system.*

2. *The axiomatic method is the construction of such an axiom-system.*

H. Weyl believes that the axiomatic method consists in collecting the fundamental concepts and relations from which all concepts and theorems of a science can be obtained by definition or by deduction. Such a statement, however, leaves open the very important questions—What are the fundamental concepts and relations? How are these determined? Russell thought that implication, negation and disjunction were the fundamental relations, but Sheffer and Nicod derive these from the stroke-function.

3. *The axioms are that sub-group of all propositions from which the remaining propositions are deduced in various ways.* It is clear that this problem is of a different nature from that of determining the *fundamental* concepts.

4. *By a proposition we mean any ordered collection of symbols having a definite truth-value.* The usual definition of a proposition as a statement which is either true or false is no longer adequate for the following reasons:

The symbols of a set (as e.g. $a \mid b$) are not necessarily statements. A definition is meaningful, but yet neither true nor false. (We refer here to definitions as $p \rightarrow q : \rightarrow : p' + q$.) This is not

to argue that definitions must be accepted without question. As Professor Smith points out, a definition that leads to a breakdown of essential distinctions must be discarded in the interest of generality. But this is done not on the grounds that it is false, but that it lacks generality. In an axiom system we do, however, assign arbitrarily a truth-value to all definitions. Lastly, there are more than two truth-values and hence Russell and Whitehead have developed a very restricted logic.[1]

5. *By an assumption within an axiom-system, we mean a proposition to which we assign at will, a truth-value.* Therefore, it follows that definitions are assumptions. It also follows as a consequence of our definition that these assumptions (or axioms) are propositions and not propositional functions. A confusion has arisen in the minds of many due to their confounding an axiom-system with the application of such a system. When an axiom-system is applied to a definite set of objects, the propositions are either satisfied or not. In other words, in application of axiom-systems, the axioms are capable of taking on a truth-value which depends upon the objects substituted for the apparent variables. Therefore, the axioms were considered to be functional. Although we might have defined a propositional function before, its definition is obvious. The set of assumptions whose truth-values are taken at will are called the "axioms" or "postulates" of the set. These constitute a sub-group of all the propositions; the remaining propositions are called "theorems" since they are derived from the axioms. Their truth-values are contingent upon the truth-values assigned to the axioms and definitions. The entire set is spoken of as "axiom (or postulate) set."

6. *By a theorem, we mean one of that sub-group of all propositions of the system which can be deduced from the sub-group of axioms.* It follows from our definitions that the axioms together with the theorems make up the whole axiom-system.

THE NATURE AND PURPOSE OF AXIOMS

We defined previously the axioms of a set of propositions to be that sub-group from which the remaining propositions can be

[1] For this reason Carnap's attempt to make a "Logische Aufbau der Welt" is misleading and doomed to failure. Carnap bases his work on *Principia Mathematica.*

deduced. It now becomes necessary to discuss the selection of these axioms and their meaning.

It has probably been noticed that the terms "axiom" and "postulate" have been used interchangeably. This is due to the fact that in dealing with abstract axiom-systems, there can be no such distinction as Euclid tried to draw. His distinction is due to the fact that he is dealing with a certain type of object, and he feels it essential to distinguish between propositions accepted as true which are about geometric constructions (as e.g. the parallel axiom) and those true but not about such entities (as e.g., if equals are added to equals the results are equal.) Analogous to such a distinction might be one between propositions dealing with logical facts (as the syllogism) and those dealing with the entities assumed in the system (as e.g. $a + b = b + a$). The former might be called postulates, the latter axioms. However even such a distinction disappears when we come to derive the system of logic. If a distinction is desired we might use that between a tautology (in Wittgenstein's sense) and a proposition not a tautology. But even this is unnecessary, because if we write down the axioms of a given system, they are all taken to be true for the objects *within that system.* In other words, the axioms within a given system are taken to be always true no matter what objects *within that system* are substituted for the variables. In dealing with general axiom systems, as we do here, one word is sufficient since the two signify the same objects. This is an example of how one starting with two words for apparently different objects has by generalization come to drop the distinction. We shall use the words interchangeably, meaning by axiom-set (or postulate set) those propositions of a system from which the remaining ones are derived.

Suppose now we wish to set up an axiom set? On what basis are we to found our selection of those propositions we are to use as axioms? and what criteria are to determine our choice?

For Descartes and the Rationalist school (as also for Euclid) axioms are self-evident truths incapable of demonstration. Since the question of self-evidence has been abundantly treated, and it has been repeatedly shown that any proposition can be taken as an axiom, we need not consider this problem here.

The first criterion that comes to mind is a minor one—that of economy in the number of assumptions. We are to select, all other things being equal, the least number of propositions possible from which all others can be derived. Clearly we might if we had before us the entire system, select all the propositions as axioms, and then have nothing left to prove. This does not take account of our demand. If we have the smallest possible number of axioms, we need not consider the other propositions since they can all be derived from these. If we have a set of m propositions and can deduce from r of them the other $m - r$ propositions and also from s of them the other $m - s$ propositions, we shall select, other considerations being equal, as our axiom set either the r or the s propositions, according to whether $r < s$ or $s < r$. Clearly if $s = r$ we must consider other criteria. If no other are available we select at random either set s or set r. This criterion for the selection of our axioms is a method applicable only if we have the entire system before us. This happens very infrequently—an example where it has happened is in the axiomatic of Euclidean Geometry (by Hilbert and others). For the most part we do not have all the possible propositions before us. Rather we are seeking the proper axioms from which we can derive the greatest quantity—despite the fact that it has been claimed by Carnap that an axiomatic is possible only when we have before us all the propositions of the system.

The question at once arises, is there any general method by means of which we can determine the smallest set of axioms necessary and sufficient for the deduction of all our theorems? If we have all our theorems before us (implying therefore that there is a finite number of them) then if we can derive all our theorems we answer the question affirmatively. If, however, we have an infinite number of possible theorems, or an unknown number of theorems, we face a very difficult problem. This has been called the Problem of Categoricity or Completeness.[2] The problem is—how are we to determine the axioms necessary and sufficient for our axiom system? This must involve the possibility of deriving

[2] Cf. Fraenkel, p. 347. And also W. Dubislav, "Die Philosophie der Mathematik in der Gegenwart," Berlin, 1932.

(or showing impossible to derive) any given meaningful theorem from our axioms. But in order to do this it is necessary to solve the "Entscheidungsproblem." This problem is to demonstrate the derivability or non-derivability of any given theorem from the axioms. Thus it is evident that the question of Categoricity is dependent upon the "Entscheidungsproblem," and the solution of the latter problem will result in the solution of the former problem.

An attempted solution of the question of Completeness for certain axiom sets (in particular the sets of Huntington and Kline on "betweenness") was given by C. H. Langford in an article entitled *Analytic Completeness for Postulate Sets* (Proc. London Math. Soc. 1926). The method he used is exhaustion of all element combinations and a proof that they are all either derivable from or incompatible with the axioms. The fact that has made the beginning of a solution of the Entscheidungsproblem so difficult has been that the Mathematician, to whom it was of such great interest, did not see that it depends upon *Logic*. If it were possible to construct all propositions whose truth is independent of the terms which enter into them, we should be well on our way to a solution. Having our axioms, which are shown to be consistent and independent, we would be able to set up all possible resultant propositions, and thus solve our problem. This is not necessarily an impossible task despite the fact that an infinite number of theorems might result. The infinite can very frequently be reduced to a finite law of generation. On the other hand, the average logician fails to consider such a problem and hence the mathematician is reduced to the solution of special cases of his problem.[3] The Logic of Modality as developed by H. B. Smith sets itself precisely that question as the general problem of logic. We do see, however, that in order to solve this problem, we must await a completed Logic. So far we can handle one case. In material implication all that is necessary is to show that the proposition in question is a tautology, i.e., true

[3] E.g. E. L. Post has offered a method for the solution of this problem in the propositional calculus by means of truth-value matrices. American Journal of Math., 1921. Cf. also Behmann in Math. Ann. 1922, Lowenheim in Math. Ann. 1915.

independent of the meanings of the terms assigned to the variables. Then it follows that the proposition is implied by the axioms since a true proposition is implied by any.

Turning now to the actual selection of axioms, we can distinguish the following methods of selection: 1) empirical 2) rational 3) empirico-rational 4) utilitarian. Although history shows that some of these methods have been advocated to the exclusion of others, it will be seen that no one of these methods alone is adequate.

The empirical method has its strongest support in the natural sciences. Here an axiom is determined by the consideration of a great many instances. In time it appears probable that a certain law explains them all. This law is then selected as the axiom from which to start. The discovery of new facts contradicting the results deduced from this axiom would necessitate a search for new axioms. There is, therefore, nothing absolute about such axioms since they depend upon the cases investigated. The axioms depend upon whether or not we *see* them in nature and are not cogent to mathematics at all. Here we ask—what of purely abstract sets? May it not be that in such sets empirical factors are of little importance? Suppose for example, I set up the following set:

1) Let there be at least three objects a, b, c and a class K of which they are elements ($a \neq b \neq c$)
2) $a + b = b \cdot c$
3) $a > b = a - c$
4) $(a + b)c = (a - c) + b$

Have I not been entirely free from empirical data in the selection of my axioms? The choice of axioms is then entirely arbitrary.

This is the ultra-rationalistic position regarding the selection of axioms. Axioms are merely arbitrary fiats of the mind. There are no essential reasons why one should select those axioms rather than any others.[4] There is no reason to select Euclid's parallel axiom, rather than any other axiom concerning parallel lines—except consistency. However, the very condition of con-

[4] "Den Axiomen kommt also keine logische Notwendigkeit zu" says Holder in *Die Mathematische Methode*, Berlin, 1924, p. 358.

sistency shows immediately that axioms are not "taken from the air," so to speak, but their selection is subject to certain conditions. It would be impossible, too, for any individual to set up axioms who had not some previous experience to suggest these to him.

When one considers the purpose of axioms in the natural sciences, the empirical criterion of the selection of axioms leads directly to what may be called the utilitarian or pragmatic criterion, (Poincaré). This briefly states that the choice of one's axioms depends on their utility. In natural science, utility is in part defined in terms of explanation and prediction of events. We are using a new term, *i.e.*, hypothesis, which leads us to a different point of view. All empirical or pragmatic criteria for the selection of hypotheses are concerned with *applying* axiom systems. It becomes necessary as a result to distinguish clearly between an abstract and an applied system. In abstract systems, no reference is directly made to empirical objects. As a consequence, empirical considerations alone are not sufficient for the selection of an axiom set. On the other hand, when axiom systems are to be applied to empirical objects, the set cannot be totally independent of empirical considerations. In abstract sets, as was pointed out previously, we used only the word "axiom"—the necessity for "hypothesis" shows at once that we are no longer dealing with such sets.

How then are axioms selected? They are *actually* suggested to us or controlled by empirical considerations, but are not *determined* by such considerations. As Dubislav points out (Erkenntnis 1, p. 37) the position that axioms are merely statements of empirical results (Mill) does not take into consideration the process of abstraction. Our experiences are searched for *types* of facts. From among these we make our selection with a certain degree of freedom. After such a selection has been made, we test the axioms for the *properties* of consistency and independence, which are considered desirable in the case of independence, and necessary in the case of consistency. Evidently if we had never come across relations which are transitive, we would probably never think of postulating an axiom as $a\ R\ b \cdot b\ R\ c$ implies $a\ R\ c$

unless it were done as a contradictory (or contrary) of another relation as in the case of the parallel axiom. Another manner in which axioms are selected, which is not directly empirical, but is based upon our experience, is by the generalization process. In this fashion axiom sets for projective geometry, or for analysis situs have frequently been constructed. If a name is desired for this method, we might use empirico-rational, or rational-empirical, or (as suggested by E. A. Singer) critical.

Suppose we wished to establish a set of axioms for the relation "betweenness." We would examine various cases where this relation held and consider further what we meant by "betweenness" and write down those properties we thought to be essential. Of course we need not accept any given property as an axiom. We might take the converse, or the contradictory. Here rational considerations begin to enter. It is a mistake to say that the selection of axioms is *purely arbitrary* in dealing with abstract sets. The insistence of the various schools on the different criteria discussed above, turns out to be due to the fact that they were considering only separate aspects of axiom-systems.

In addition to the elements mentioned there are a number of what may be called time-conditioned elements. Naturally we desire our system to be as general as possible. Hence an important criterion for the selection of axioms is generality. But can any method be found for the solution of this question, since it seems to involve a circle, i.e., is the method for testing generality, general? It becomes necessary to consider generality as closely as we consider consistency. It is possible to determine the conditions for consistency from its definition. We cannot succeed in a similar attempt for generality. For a proposition to be completely general it must be possible to state whether it is true for every permissible value or not. If we are concerned with a finite quantity of values, the problem can be answered, otherwise not, since although it is possible to define a set of values by a function, the only way to determine whether any given value satisfies the function is by trial. In short, we can only say of an axiom that it is completely general *so far as we know.* It will be seen to lack generality if a value is found to which it does not

apply. Thus we might take the Pythagorean theorem or the Fundamental Proposition of Algebra as an axiom. These are *general* since they apply to all permissible values. But they would not be general axioms, since we could deduce these and other theorems from more general statements, while we could not deduce some theorems from these. This problem is also related closely to the question of Categoricity.

Further light is thrown upon these criteria by consideration of the purposes of axioms. What are the axioms supposed to do? Returning to a consideration of the postulate set given previously, we notice that it begins with the assumption that there exists a class K, etc. This is evidently one of the purposes of our axioms —to assume the existence of certain entities. It is to be noticed that some of these entities are not further defined, while others are defined in terms of these. We might call these undefined elements the *atoms* of the system. Then the first purpose of our axioms must be to establish the existence of the atomic elements of our system. Although it has been said that these elements are undefined, this is not precisely true. One must distinguish between various types of definition—implicit and explicit. Both these types are exemplified in an axiom system. The atomic elements of the system are implicitly defined by the entire set of axioms. These axioms delimit the properties which the assumed entities are to have and therefore delimit also the various fields of application or possible representations of the axioms. This is an important purpose of the axiom set as a whole—to define the area of applicability. Very frequently an axiom is inserted or removed with the express purpose of either increasing or delimiting the sphere of applicability. For example, Fraenkel[5] wishes to exclude those aggregates of the Mengenlehre that lead to paradoxes. In order to achieve this goal he includes another axiom in his set which limits the generality of the variables involved. It goes without saying that such a method must be used with great care. The generality of the variables must be as complete as possible, and therefore if an axiom is introduced which limits

[5] Einleitung in die Mengenlehre, p. 247.

such generality, the system will lack generality, and hence may have to be rejected.

Our axioms must, if they are to be of use, assume the existence of certain operations as e.g., addition, negation, etc. This is necessary in order to proceed. With entities alone nothing further can be done. But with entities and operations, we can derive new entities and then proceed to our consequences.

When in *Principia* Russell says that "A definition is a declaration that a certain newly-introduced symbol or combination of symbols is to mean the same as a certain other combination of symbols of which the meaning is already known. . . . It is to be observed that a definition is, strictly speaking, no part of the subject in which it occurs," he is thinking of a special type of definition exemplified by such symbolic expression as

$$p \rightarrow q \cdot = \cdot p' + q$$

where all that is meant is that one name is to be used instead of another. This is the nominal definition. There is, however, another type of definition in addition to the two mentioned, exemplified by

$$a + b = b + a$$

i.e. the explicit attribution of a definite property to an operation. This type of definition in verbal form is usually recognized by the words "such that" and is of very frequent occurrence in mathematics. As e.g. if f(x) is a function *such that* given any ϵ there exists a δ such that when $|x - x_1| < \delta$, $|f(x) - f(x_1)| < \epsilon$ then f(x) is said to be continuous. That there is another type of definition has been recognized by many. Peano insists[6] that definitions of new symbols in mathematics (and this applies to any system) must satisfy certain conditions i.e. they must at least not lead to a contradiction of an axiom. He gives as an illustration the introduction of the symbol (?) defined as follows:

$$\frac{a}{b} ? \frac{c}{d} = \frac{a + c}{b + d}.$$

[6] Les Definitions Mathématiques, Bibliotheque due Congrès International de Philosophie 3, 1901.

But this symbol, Peano says, cannot be accepted because if $a = 2, b = 5, c = 7, d = 11$, we have

$$\frac{2}{5} ? \frac{7}{11} = \frac{2+7}{5+11} = \frac{9}{16}.$$

And if we substitute $\frac{4}{10}$ for $\frac{2}{5}$, by the axiom that equals can be substituted for equals, we get

$$\frac{4}{10} ? \frac{7}{11} = \frac{4+7}{10+11} = \frac{11}{21} \neq \frac{9}{16}.$$

Therefore this definition must be rejected. So it becomes an important purpose of axioms to limit proper definitions, especially for the case of the necessary relations.

If we make suitable distinctions between types of definition, the purposes of our axioms can be reduced to two general heads: 1) to postulate the existence of certain entities; 2) to define entities and relations.

It was perhaps the failure to see this point that caused Plato in the Republic, to criticize the use of axioms, or as he calls them, suppositions, on the grounds that it is not possible "to call science a discipline which is ignorant about its beginning, and whose middle and end rest on something which it does not know (533)." Plato would base mathematics on pure definition. On the other hand, we find this doctrine fully recognized in Oskar Perron—*Uber Wahrheit und Irrtum in der Mathematik* (p. 196 ff. Jahresb. Deut. Math. Verein. v. 20), where he points out that axioms are really substitutes for definitions or rather implicit definitions.

However it must be made clear that at the bottom of every postulate set, except the logical set, is a rule or method of drawing inferences. This is taken from logic, and hence it is felt to be unnecessary to write these down. The mathematician who is endeavoring to build up his system, justly assumes that the logician has done his work properly, and he can therefore build on the results of the logical system. In other words, we have in every axiom set an implicit method of proof which Hilbert indicated by the schema

$$\frac{p}{p \rightarrow q}$$

The simplicity of this schema is due to the fact that Hilbert, as we have seen earlier, assumes that Russellian logic is completely general and accept Russell's definition of the $\rightarrow$.

The fact that the introduction of axioms is often made in order to delimit our field of application, has already been mentioned. There is another purpose of axioms. To illustrate: suppose we have the following axioms.

1. There exist at least two elements a and b, a $\neq b$.
2. $a + b = b + a$.
3. $a + o = a$.
4. $(a < b)\ (b < c)$ implies $(a < c)$.

Without any further axioms there are a wide range of objects for which these could serve as a foundation for the development of formal properties. To mention only a few: the set of numbers $\{2, 3\}$; the set of classes, etc.

If now I add the further axiom

5. $a \cdot a = a$.

certain possible applications drop out e.g. I cannot use the set for numbers. This is not to imply that there is one and only one application for every set of axioms. Nor does it imply that there must be an interpretation (although the existence of an interpretation shows the set to be consistent). A postulate set (if consistent) describes the structure of a *possible* system of entities. And as Eaton says "A postulate set is not dependent on any single interpretation, it deals with possibilities—and if it had no interpretation it would still describe the structure of a possible system though it would be of little interest to mathematics," (but cf. Theorem 30 in next article). The postulate set prescribes the universe of objects (or types of universes) to which it may be applicable. Axioms define the type of objects satisfying them, and cannot be merely rules of a game played with meaningless symbols. Dubislav[7] does admit that these "games enable men to use the objects of their environment." This applicability of a postulate set seems to be overlooked by those who following Wittgenstein, wish to reduce all logic and mathematics to tautologies. Cer-

[7] Erkenntnis 1.

tainly, if we take what I think Wittgenstein means by tautology (i.e. a proposition true for any values assigned to its variables) as the definition of a tautology, then an axiom cannot be a tautology.[8] Axioms as we have seen are true only for certain ranges of values. They select as Langford[9] points out, from among alternatives, and hence cannot be universally interpreted. Nor can we see how "the *union* of a postulate and a theorem" constitutes a tautology in this sense, as Weiss[10] wishes to have it. If the postulate is true for a range of values, the theorem is true, either for the same range of values, or a sub-set of this range of values. Furthermore, all this assumes that the truth-value of axioms is "true" or "false." Of course, it need not be, and hence we are faced with the problem of deciding what truth-value the theorem itself has.

It is claimed by some that axioms are propositional functions[11] and at the same time tautologies. It is now evident that if axioms are tautologies they cannot be propositional functions. By definition the truth or falsity of a propositional function is dependent upon the meanings assigned to the variables, but a tautology always is true, and therefore is independent of the values assigned to the variables. The confusion has arisen again because of failure to note the distinction between an abstract set and an applied set. It is true that any given axiom becomes true or false, depending upon the value assigned to the variable when it is considered apart from the other axioms. Together with the other axioms, a new universe of discourse is defined, and as a result, the axiom's truth-value is so far definite, and not variable for the values in this universe of discourse. An axiom then considered in its context is not a functional expression, but has a truth-value assigned to it. This truth-value has usually been taken as truth—but that is not forced upon us.

[8] Carnap defines a tautology as a proposition which is entailed by every proposition (*Philosophic Problems* in *Philosophy of Science*, January, 1934, p. 11) but this is equivalent to the definition given since every proposition implied by *any* proposition is a true proposition.

[9] Proc. London Math. Soc., 1926, p. 17.

[10] Nature of Systems, Open Court Publishing Co., Chicago, p. 43.

[11] Carnap, "Bericht über Unterzuchungen zur Allgemeinen Axiomatik," Erkenntnis 1, p. 303.

It does not follow from what has been said that the particular axiom represents an expression meaningless in itself, as Fraenkel maintains. It cannot be meaningless, (i.e. applying to no universe) else how could we find interpretations for it? If the particular axioms were each meaningless, i.e. without application, there would be no reason to suppose that the group would have meaning, even if it is true that the properties of the group differ from those of its parts. Again, if the proposition were meaningless, how could we ask if it were consistent with, or independent of, the other axioms? The particular axioms must be meaningful if we are to have an axiom system.

From the fact that an axiom is not a tautology, and from the various purposes and nature of axioms, we must conclude that an axiom cannot be absolutely true and incontestable. If an axiom does not satisfy the purposes it is supposed to, it cannot be used. If it forces the introduction of unwarranted entities, or the exclusion of necessary entities, it must be rejected. Thus it has been claimed that the famous Zermelo axiom (often called the Multiplicative axiom) introduces an impossible operation, and as a result this axiom has been contested. Aristotle (An. Post. I, 2) believed that demonstration is by means of pre-existing knowledge which is better known than the conclusions to which the premises are prior. Due to the development of axiomatics we see that no axiom can be considered so self-evident that it may not be subject to scrutiny. Very frequently self-evident axioms can be deduced from other axioms not so self-evident, and then the former become theorems. To quote Lewis "Today . . . when 'postulate' or the colorless 'primitive' propositions have replaced the self-evident axiom, when non-Euclidean geometries have been recognized to have precisely the same logical structure as Euclid, and when it has been shown that various sets of postulates may give rise to the same deductive system, we have less than no excuse for retaining the notion that a presupposition is more certain than its consequences."

THE NATURE AND PURPOSE OF THEOREMS

The axioms as we have discussed them, are only a subset of all those propositions which constitute an axiom system. We now

consider the remaining set of propositions which can be derived from the axioms. We call such propositions the theorems of our system. Since the theorems are derived from the axioms, it follows that a great deal, if not all that was said about the axioms, is true also of the theorems.

In discussing Brouwer we noticed that he appeared to be pointing to a more general logic. His position seemed to imply that even if the axioms are taken to be of truth-value 1, the truth-values of our theorems are not the same. The true can imply the possible, but not conversely. The true implies the true only under certain conditions. Thus in the solution of the paradox, it was suggested that all that was proved was the possibility of a certain proposition being true. Can it be that the truth-value of the theorems is, therefore, less than, or equal to that of the axioms? We see now the possibility of a new development. What is the value of our theorems when the axiom has any given truth-value? We previously defined an axiom as a proposition to which a truth-value V_1 was assigned at will. The theorems then will have their values less than or equal to V_1. The question arises then, what about our original set of propositions? If our axioms were selected from all these, and none were by nature such that we *had* to select them, do not the theorems have the *same* value as the axioms? To this we reply, that *ab initio* the set of propositions have no truth-value. When we select certain of them to be our axioms, we assign a value. Naturally, the values of certain others (namely their contradictories) are then determined. But the remainder have no truth-values as yet. They only acquire such values after being deduced or shown impossible to deduce from the axioms. Because theorems are supposed to follow logically from axioms, it has been assumed that they have the same value as the axioms. And since in a two-valued logic we have only zero and one, the whole system is taken to be true. Neither of these assumptions is justified. The fact that theorems follow from axioms gives us only the right to say that their values are less than, or equal to that of the axioms. The fact that there can be more than two values throws the resultant value of the theorem into ambiguity.

Theorems are derived from axioms (or other theorems) by three methods:

1) Direct substitution;
2) By application of the sorites;
3) Indirect methods.

It is advisable to consider another sense of the word tautology. Theorems are sometimes said to be tautologous in the sense that they are already contained in the axioms. A theorem may give birth to new entities by operating upon the old—and this new entity is, to be sure, composed of, or rather built by means of the other entities, but it may have new properties which its constituents do not have. For example, $1 + 4 = 5$, defines a new element which has at least the additional property of being greater than 4. Hence again, we cannot say that the theorem "5" merely repeats the premises of Arithmetic, although it is implied by them.

PROPERTIES OF POSTULATE SETS

In this section we return again to the postulate set in order to define certain properties which the set as a whole must have in order to be acceptable and applicable.

Although theorems may be propositional functions, the axioms are not. It has been argued that because the theorems and axioms are functional in character, the system is also. That this is a fallacious argument is, I believe, evident. It commits the fallacy of attributing to the whole the properties of the parts. But despite this, the axiomatic system is, in one sense, at least, functional in character. It is a form which can be imposed upon *possible* sciences. That any one type cannot be applied to all sciences is evident from the fact that there are different types of axiom systems whose properties are defined by the axiom. But we cannot speak of the truth-value of a system, but only of its applicability. For this reason it is well to adopt the expression "doctrinal function" used by C. J. Keyser.[12] This term avoids the implications of "propositional function," yet keeps the con-

[12] Journal of Philos. Psych. and Sci. Methods 15, 1918. "Doctrinal Functions."

notation of its hypothetical character. A doctrinal function is to be conceived as a framework of a science.

Postulate sets in themselves must have certain properties. In discussing criteria for the selection of axioms, we noticed that we are to choose the least number of axioms necessary and sufficient for the deduction of all theorems. It was then seen that this involved certain problems of interest for postulate sets, and that these problems were not separate and distinct, but related in such fashion that to solve one would be to solve another—or at least to lead to a solution of the others. It was also suggested there that a real solution of all the problems awaited the completion of logic.

In the first place, given any axiom set, if we are to satisfy the criterion just cited, we must show that no axiom can be derived as a theorem from the others, and that no axiom can be dispensed with. Suppose we have a set of axioms which are assumed to be independent. To omit one or more of the axioms will leave us an independent set of axioms. This sub-set and its theorems will constitute only a sub-system of a more complete system. In other words, an axiom which is needed to complete the system, i.e. without which we cannot derive all possible theorems, is an axiom which cannot be dispensed with. The problem of determining whether or not we have all necessary axioms is called the problem of *Completeness*. It is evident that even if we can show a set of axioms to be independent, we have not shown them to be complete, nor if we have shown them to be complete have we necessarily shown them to be consistent. But if we have shown a set to be independent and complete, we have then shown it to be necessary and sufficient for the system in question.

If we could set up all the true and false propositions whatever which follow from any given set of axioms (if only in a law-abiding fashion, i.e. in functional form) both the problems will have been solved. Meanwhile, it is necessary to be satisfied only with partial solutions. Thus C. H. Langford proves completeness for certain sets of postulates by setting up all possible combinations of the terms and axioms in functional form, and then showing by analytic methods that they are all either inconsistent with or

deducible from the given set. This is really an attempt to set up all possible true and false propositions involving the concepts and axioms under consideration. The more general problem of Logic when solved will be a generalization of this method. In the meantime, analysis of special cases with the resulting description of the properties of these properties is invaluable in order to enable us to avoid false tests for these properties.

The more general problem of the necessity and sufficiency of a set of axioms for a system we shall call the problem of Categoricity. No precise distinction seems to have been made between this property of Categoricity and the property called "Entscheidungsdefinit." That they are related will be evident but we shall now avoid confusion between the two by adopting categoricity of a set, to denote its necessity and sufficiency. Thus we must conclude that independence and completeness are special problems that go to make up Categoricity. Categoricity can be determined only after logic has been completed. The failure to note the non-generality of independence has led to many confusions, and false attempts to set up criteria for it. Since independence is a special case, we may, however, be able to set up special criteria for it.

The mathematician has argued on the basis of the law of excluded middle that every meaningful problem can either be solved or shown to be impossible. As a consequence, he has been very optimistic with respect to all sorts of problems. For thousands of years mathematicians have attempted to square the circle or trisect an angle, feeling that sooner or later he would either solve them or show them to be incapable of solution. The transcendence of π and the fact that the trisection of an angle involves a cubic equation which in general does not have real rational roots, shows both problems to be impossible, and has increased the faith of the mathematician in the doctrine—*every problem has a solution, or can be shown to be impossible.* The question arises—is there a general method by which we can answer the question, given any problem, without actually deducing the problem? This is the problem called the "Entscheidungsproblem." Any system in which this problem can be solved is called "Entscheid-

ungsdefinit." Here again solutions have been given only for special cases. For example E. L. Post has solved the problem by means of truth-value matrices for the calculus of propositions.[13] The method of Post is, however, not for the general calculus of propositions, but only such as admits material implication alone.

It is easy to see how this property is related to Categoricity. If we have solved the problem of Categoricity we have solved the Entscheidungsproblem, since with the solution of the former problem we shall know what theorems are deducible. Therefore, given any problem, we can tell whether or not it can be solved. But again the converse is not true, having solved the Entscheidungsproblem for any problem we have not solved the Categorical-problem. We shall have done so if we have solved the Entscheidungsproblem for *every* possible problem. Here again we must reject material implication; since any true proposition can be derived from any proposition, it would follow that a proposition such as $2 + 2 = 4$, can be deduced from any set of axioms, even such as are outside its universe of discourse. As we saw a set of axioms defines its sphere of applicability—we might say its universe of discourse,—all these problems which we discuss here become meaningless (with the possible exception of consistency) if the given propositions are outside the universe of the axioms.[14] Hence material implication which connects propositions in different universes of discourse, is not to be considered with respect to these problems.

It is again evident that if we solve the general problem of logic, the Entscheidungsproblem is also solved without further ado.

Given any proposition, it is then to be decided whether or not it is deducible from the given axioms. Unless the given proposition is consistent with the axioms, it cannot be deduced from them. This is not to say that if it is consistent it can be deduced.

[13] Cf. also H. Behmann, in Math. Ann. 1922, and Bernays and Schönfinkel, Math. Ann. 1928. Post's article is in American Journal of Math. 1921.

[14] This idea is due directly to Prof. H. B. Smith who suggested it during the course of a discussion with the author on these problems. This explains the way in which such a remark as Prof. Lewis makes that no two propositions can be consistent and independent at the same time, can be shown to argue against material implication.

Consistency and deducibility are of course not the same. A proposition may be consistent with other propositions, yet not be deducible, as is seen in the case of a consistent, independent set of axioms. But if the given proposition can be shown to be independent of the axioms, it would follow that it cannot be deduced from them. Thus the question of whether or not a proposition is deducible, is essentially connected with the problems of independence and consistency. If we can show a given proposition consistent with the axioms from which we wish to deduce it, then we have increased the probability that it *can* be deduced. We can say that the given theorem is either an axiom or a theorem in the system. If it is an axiom, it must be independent of the other axioms. Then if we can show it independent, we have proven it an axiom. If not, and we cannot show it non-independent, our problem remains unsolved. The importance of a general method of independence proof is evident. With the solution, again, of the general problem of logic, we will be able to distinguish from the formal properties of the given proposition whether or not it is deducible. Independence and consistency are the necessary and sufficient conditions for a proposition to be non-deducible (i.e. for the negative reply to the Entscheidungsproblem for that proposition).

We have been discussing the importance of Consistency and have not defined that property. For the time being we can use the ordinary definition of consistency—namely, a set of propositions are said to be consistent if it is not possible to deduce one of these and its contradictory from the same set as theorems. Clearly any proposition is inconsistent with its contradictory. This is, of course, a negative condition, and hence a precarious one. Meanwhile, it is sufficient to point out that consistency is of prime importance for a postulate set, even if in itself it is not sufficient. If a set is inconsistent, any theorem whatever can be deduced, and the whole set reduces to absurdity. But even this important property is closely related to the more general problem of finding necessary and sufficient conditions for an axiom system. If a set is not consistent, it is clearly not sufficient for our purpose. And if we have a necessary and sufficient set of axioms, the axioms

will be consistent. Until, therefore, we can solve the more general problem, we must be content with the solution of special cases. It must not be forgotten that a set may be independent and consistent without being necessary and sufficient. As a consequence, the problem of Categoricity is the most general problem;—all other problems being special sub-divisions of this problem. And as it was seen that this problem cannot be solved until a complete logic has been developed, it follows further that all these problems will be solved completely with the completion of Logic.[15]

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[15] Due to its technicality, the remainder of this analysis will be published as a Supplement to this Journal.

Psychology: The Propaedeutic Science

BY

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PREVIOUS claims that psychology is propaedeutic to the other sciences have been met with enthusiastic indifference. Contributing to this indifference has been the fact that psychology, a young and unproved discipline which habitually borrowed the methods of the older sciences, has too frequently revised its notion as to its own nature and subject-matter. More important, however, has been the faith of the physical sciences in the absolute character of their own basic concepts: in the reality of Absolute Space and Absolute Time and in the universality of deterministic principles, for, as long as physics presumed to deal with entities which are what they are regardless of the nature of man, nothing other than these entities appeared to demand prior consideration. The problem of the nature of the observer in the physical experiment became important to physics only as a consequence of the recent 'subjective' revolution. It is this revolution which has revitalized the problem of the propaedeutic science and has accentuated the distinction which we must make between the behavioral phenomenon of individuals creating formal arrays of words or symbols which are without operational meaning and the discriminatory responses, or operations, by which the empirical meaning of such arrays is determined.

ANTECEDENTS

Wilhelm Wundt fathered the view that the subject-matter of psychology is immediate experience. The subject-matter of physics, then, must be mediate experience since its data and concepts are inferentially derived. But since immediate experience is antecedent to mediate experience it would appear that psychology must be antecedent or propaedeutic to physics. All very well, except for the fact that the historical development of the sciences seems to deny any such relationship. Indeed the historical perspective renders somewhat ridiculous the picture of a German professor implying late in the nineteenth century that his newly founded science investigates the phenomena which determine what physics can or cannot be.

Avenarius, and later Titchener, appeared to relieve the embarrassment of Wundt's position by distinguishing between psychology and physics on the basis of their points of view. Psychology and physics both treat experience, but psychology regards experience as dependent upon the individual while physics regards it as independent. We might have contended ourselves with this dictum, except for the fact that the experience in question was not adequately defined. If we are to understand by experience the sort of thing spoken of as immediate experience, we find ourselves in the vertiginous position of trying to reconcile the notion that out of our experience comes the concept of the brain as a physical entity and at the same time out of the functioning of the brain come our experiences.[1]

At this point Stumpf proposed to rescue us by ordaining a third science, phenomenology, which has as its subject-matter the phenomenal data of experience and which is therefore a *Vorwissenschaft*, propaedeutic to both psychology and physics. This treatment, however, was open to all the objections raised against immediate experience, plus the complaint that a workable operational definition of the subject-matter of phenomenology has never been formulated.

[1] Cf. discussion by E. G. Boring, *The Physical Dimensions of Consciousness*, 1933, Chap. 1.

In brief, then, we find that many of these claims of psychologists, regarding the systematic status of their science, have not been taken seriously, chiefly because:

1. The idea that psychology is the propaedeutic science was in apparent conflict with the obvious truth of history.
2. The nature of physical science itself was not well understood.
3. Satisfactory definition and understanding of the nature of psychology and the meaning of the term experience were wanting.

We might profitably drop the matter at this point and relegate all future discussions of it to the historical texts were it not for the fact that important changes have overtaken to the physical and the psychological sciences since Wundt first distinguished between them. Psychology has found itself, and physics has refound itself, in ways which coordinate their methodologies and clarify their relationship.

Before going on, however, we should accord a word of dismissal to the 'historical' objection to the propaedeutic status of psychology, for the fact that physics is chronologically psychology's senior is irrelevant. Euclid's geometry preceded the development of topology by more than two milleniums, but topology is the more basic discipline. In fact the story of almost every science shows that only after a super-structure has been erected and embellished do men inquire into the nature of the foundation stones. Such in particular has been the case in physics.

THE REVOLUTION TO RELATIVITY

Newton likened himself to a child playing on the seashore while a vast ocean of truth lay undiscovered before him. Following Newton men bent their efforts toward exploration of Newton's ocean, believing as Newton did that Truth, eternal and absolute, lay as islands waiting to be come upon. The Laws of Nature were things to be discovered, rather than invented, and concerned a universe in which events occurred at certain places in Absolute Space and at certain instants in Absolute Time. A body at absolute rest remained so unless acted upon by a force, having an absolute magnitude, which then became the cause of its motion. There was no change of motion without cause, and the firm faith

was that knowing all antecedent conditions one could predict all subsequent events. In a word, the naïve realism of the Newtonian view left the experimenter and the problem of his nature and limitations quite out of the picture.

However, when it became a question of measuring Absolute Time in order to discover whether two events were simultaneous, Einstein discovered that he was at the mercy of his clocks, of the speed of light, and also of the nature of the observer. Likewise, when Michelson and Morely set out to determine the absolute motion of the earth, they discovered themselves limited by the measuring rods which they were forced to use, and these rods in turn were suspected of changing length as they moved. What, then, is the significance of the elusive nature of the Absolute? The answer is given in the notion of relativity.

Nowadays we concede that the purpose of science is to invent workable descriptions of the universe. Workable by whom? By us. We invent logical systems such as language and mathematics whose terms are used to denote discriminable aspects of nature and with these systems we formulate descriptions of the world as we see it and according to our convenience. We work in this fashion because there is no other way for us to work. All of our measurements are relative, dependent in the last analysis upon the nature of the operations which an observer is able to perform. Further we have to concede that the process of observation is simply an interaction between the system under observation and the observer. Consequently the presence of the observer has a definite effect upon the system and, as Heisenberg has shown, may land us in a region of indeterminacy if we try to push our precision too far.

Finally, it must be laid down that when we have formulated a description by way of experimenting and observing, the meanings of our words can never transcend the operations which went into their determination; or as P. W. Bridgman has shown, a word has meaning only if and as it stands for certain concrete operations which can be performed by the normal human being.

The overthrow of scientific Absolutism we might, for obvious reasons, call the 'subjective revolution,' but, since we should

mean by such a phrase nothing other than that the relativity of the system to the observer of the system has come at last to be recognized, we can afford to dispense with a dramatic slogan. At any rate, it has now become clear that the nature of physics is conditioned in part upon the nature of the human experimenter. Furthermore, since it is the business of psychology to investigate the characteristics of the observer, we now have valid reason to propose psychology as the propaedeutic science.

Psychology studies the nature of the organism which determines in part the nature of science. But, it will be objected, this is equivalent to saying that psychology studies the organism which determines the nature of psychology—an obvious circle. The proper answer is that the statement is circular, but none the less true. The statement is circular, because, whether we like it or not, we are dealing with a universe of continuities with no ends to grasp. Nevertheless we must start somewhere, so we plunge *in medias res*, and, although we then face the problem of an infinite regress, we try to understand rather than to worry about it. The paradox of a science, which investigates the peculiarities of the observer which determines in turn the peculiarities of the science, is readily resolved when we examine more closely the nature of psychology.

THE FUNDAMENTALS OF PSYCHOLOGY

Operational[2] psychology, like operational physics, acknowledges the relativity of all things and procedes forthwith to dispense with all concepts of absolute entities, forces or states and other metaphysical notions for which there exist no defining operations. A word or statement means something in psychology, as in physics, only if the criteria of its applicability or truth consist of concrete operations which can be performed. These operations may be of various orders of complexity, ranging all the way from intricate experimental procedures to the simple operation of noting the presence or absence of a thing, i.e., making an elementary discrimination. Complex operations are always reducible to more

[2] S. S. Stevens, The operational basis of psychology, *Amer. J. Psychol.*, 47, 323–330 (1935).

simple discriminatory acts, and all 'explanations' consist of detailing a complex set of operations in terms of simpler ones—simpler, that is to say, to the listener. The elementary discriminatory reaction on the part of human beings, then, is the fundamental operation of all science; and by discrimination is meant the concrete, 'physical' reactions of the organism to either internal or external environmental conditions.

In thus placing discrimination at the basis of all science we allow it to usurp the position formerly enjoyed by 'experience' or the 'immediately given.' Does this substitution mean that experience and elementary reactions are equivalent? It does, precisely. Any attempt to define the term experience operationally[3] or point out what, concretely, is meant by the philosopher's 'given' discloses at once that the discriminatory reaction is the only objective, verifiable thing denoted. Scientific psychology is operational and as such can have nothing to do with any private or inner experience for the simple reason that an operation for penetrating privacy is self-contradictory. Therefore, we need no longer think of immediate experience as the subject-matter of psychology and the basis of physics; instead we may say that the differential reaction makes physics possible and it is the business of psychology to investigate the nature of such reactions.

Now in respect of the problem of the experimenter, we must note that it is his business to make observations (or discriminatory reactions) and report them in words or symbols whose operational basis is as self-evident as possible. As a psychologist he observes the reactions of another human being and what is even more interesting, he may himself be observed by another experimenter who may in turn be observed, so that we pass again into a potentially infinite regress. As we have already seen, we must disrupt such a regress by stopping it arbitrarily at some point. In other words, in admitting any item to the body of scientific knowledge, we assume at some stage an independent experimenter whose qualifications to observe and record data are not in question. Someone, B, of course, may challenge a particular experimenter,

[3] S. S. Stevens, The operational definition of psychological concepts, *Psychol. Rev.* 42, 517–526 (1935).

A, and proceed to prove him in error. In this case we have pushed back a stage further along the regress; but, if we are to stop there, we again have accepted experimenter B as competent without question. And so on.

Since the psychologist is in the peculiar plight of being able to note his own reactions (we used to say: "observe his own consciousness"), operational psychology has to be careful to distinguish between the function of experimenter and subject. In the rôle of experimenter the psychologist can observe the behavior of both himself and his friends, but it is crucial that he treat his own reactions (introspections, key-pressings, etc.) exactly as he treats the reactions of others. In other words, the psychologist deals exclusively with the "psychology of the other one," even though looking at himself, and, if we choose to accept his reports about or as his own reactions, we are accepting his word as a competent experimenter regarding a concrete phenomenon he has observed. A steadfastly objective outlook of this sort avoids the dangers of the slough of subjectivity and makes possible a straightforward scientific epistemology, according to which an independent experimenter, about whom we ask no questions, investigates the natural phenomenon of knowing in 'the other one.' Such is perhaps the only *scientific* epistemology possible.[4]

The obvious importance of the experimenter's testimony in the operational scheme leads us to inquire as to the grounds of its acceptability. We have no formal yardstick by which to gauge an experimenter's worth, and yet we are faced with the fact that certain results do get into the scientific textbooks and that certain others are rejected, not because they satisfy or fall short of some absolute standard of merit, but simply because they meet with the approval or disapproval of other scientists. Each experimenter, then, depends upon the approval of his associates. If he reports seeing things which no one else is able to see, or if he hears voice which never speak to his colleagues, he is looked

[4] Nothing attests more convincingly the futility of the approach to epistemology by way of the immediately given, a private affair of mine alone, than the fact that such procedures have never got us anywhere. Cf. the review of the situation given by P. A. Schlipp, *Philos. Sci.*, 2, 128–138 (1935).

at askance. If he proves dangerous, he is forcefully retired from the community of his fellows.

In the same manner, knowledge itself and all that passes for scientific truth is conditioned upon its social acceptance. The 'true' value of a physical constant which a physicist looks up in his handbook is true because physicists agree that it is true, and, if someone convinces physicists that the value is not true, it will thereafter be false. Of course each individual may think that he has his own private standards of truth, but then so do the inmates of our psychopathic hospitals. The only difference is that the scientist's standards (*vide infra*) conform to those of his associates. As all of the misunderstood Napoleons of the psychopathic wards could testify, from the social criterion of truth there is no appeal.

Insistence upon the social criterion of truth[5] inevitably emphasizes the relativity of it. Truth is no more absolute than space or time. In fact science can speak of truth only as of a certain place and date, for what is true to-day was not true yesterday and may not be true to-morrow. Furthermore, truth to-day is not something definite and precise, of which one can take a convenient inventory, for agreement as to fact is never complete and opinion is in a perpetual state of flux. Knowledge, or truth, then, is not static, absolute or 'discoverable' in Newton's sense; it is dynamic, restless and relative.

So much, then, for a brief review of the operational basis of psychology. We see that psychology studies the behavior of a physical reacting organism and invokes the same principles of procedure as to the physical sciences. It takes for granted an experimenter capable of observing and recording objective phenomena and insists that his reports be made in terms for which there are operational definitions. Thus it refuses to recognize any but the public, reported aspects of behavior, and it acknowledges the social criterion of its truth. Psychology differs from

[5] Philosophy, for all the questing it has done in search of truth, has, in the opinion of some of its own, for example, C. J. Ducasse, *Philos. Sci.*, 2, 121–127 (1935), failed to build up a body of *accepted* knowledge. To that extent it has no truth in the present sense. The same can be said of those other diciplines which produce less and less agreement the more earnestly they are pursued.

and is propaedeutic to physics in that it follows further back along the experimenter-regress, and inquires into the laws of behavior under which men spin hypotheses, observe events, and construct generalizations.

THE EMPIRICAL AND THE FORMAL

In common with every science psychology must divide its labors into two parts; it must perform experiments and it must describe the results. Conceivably the experimenter could acquaint his public with his activities by some sort of pantomime performed in their presence, but, fortunately, he does not have to resort to histrionics except in special cases. Instead he employs a common symbolic medium. He allows certain symbols (words, letters, operators, etc.) to stand for the various objects and relationships about which he desires to convey information, and these symbols he strings together according to some set of rules (logical, grammatical or mathematical). The experimenter then relies upon such a series of symbols, which he has set up, to take the place of his actual experiment, even after the apparatus has been dismantled and put back on the shelf.

Retreating a stage in the experimenter-regress in order to observe the behavior of the experimenter, we note that the process of juggling symbols may take two distinct forms. Between them we must distinguish sharply. Our experimenter may take pains to use only those symbols for which there is some concrete denotation and for which the meaning is operationally secure. In that case we say he is making *empirical* statements. On the other hand, he may use symbols for which there is no operational definition and put them together with regard only for the rules of syntax governing the use of those symbols. We say then that he is making *formal*[6] statements (metaphysics, mathematics, hypotheses, etc.), devoid of *empirical* meaning. Of course, there is the third case in which, like Gertrude Stein, he would produce word

[6] The word formal is used here to include such diverse fields as mathematics, metaphysics and certain kinds of fiction and poetry, because they have as a common feature the fact that they consist of arrays of symbols without operational meaning—regardless of whatever other diverse and important values they may have.

arrays with regard neither for syntax nor for empirical denotation, but we can consider such cases as atypical behavior.

The generation of acceptable *empirical* statements about the universe is the primary aim of science. Observing the experimenter in his effort to carry out the empirical task, we find him for the most part wrestling with the problem of fitting the syntactical shoe to the observational foot. He generally accepts the linguistic and mathematical conventions of the day—he leaves their probing to the Logical Positivists—and tries to utilize them to represent his observations and conclusions. As a criterion of his success he has the principles of operationism by which he can determine whether he speaks sense or nonsense.

Although, as we have noted, the success of the scientist in establishing his propositions and adding thereby to scientific knowledge depends upon the willingness of society to accept his statements, certain qualities, nevertheless, appear to characterize acceptable assertions. These qualities we may term *correspondence* and *coherence*. Propositions with empirical meaning must denote (correspond to) concrete verifiable operations. The degree of the correspondence, like the precision of the operations themselves, may vary over wide latitudes, for the evident reason that the criteria, by which some words (such as *institution*, *scientific*, etc.) are applied to objects or events, are not precise. However, there must always be some criterion of applicability or the word is operationally meaningless, i.e., it corresponds to nothing at all. The quality of coherence, on the other hand, is a characteristic of the symbolic system used in making a statement. If language is used, the rules of syntax for that language must not be violated. If mathematics is employed, the treatment must be consistent with mathematical convention which, at the time, is accepted as being coherent in logical structure. The problem of the revision of syntax in an effort to attain greater coherence is the problem of the philosopher, says Carnap.

Although efforts have recently been made to distinguish two types[7] of empirical statement, the 'language of data' and the

[7] The distinction has been made by M. Margenau [*Philos. Sci.*, 2, 48–72 (1935)] between *data* and *constructs* and by H. Feigl [*Philos. Sci.*, 1, 420–445 (1934)] between the *language of data* and the *language of constructs*.

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'language of constructs,' it appears evident to the psychologist that the dichotomy is artificial. A statement about a datum is a statement about a construct. The simple statement, "I see red," is a complex response conditioned upon previous training and present circumstances of an organism, and differs only in complexity from a statement such as, "the oscillograph shows that the discharge takes place at a potential of 80 volts." The notion of a language of data is reminiscent of the concept of an absolute 'given,' and since it can be shown that the immediately given experience is defined operationally as consisting of relatively elementary differential responses, we had best dispense with the distinction between data and constructs. There are only constructs—of various orders of complexity and inference.

The activity of the scientist or philosopher when dealing with *formal* systems, constructing word arrays or manipulating mathematical signs, is an interesting behavioral phenomenon. As Wittgenstein[8] said, "Philosophy is not a theory but an activity." In spinning a metaphysical system, in solving an equation, in making a logical deduction, or in writing the "Jabberwocky," men are behaving according to some learned pattern or according to a set of rules which tell them that, having done such and such, they must do so and so. Contrary to popular belief the product of such activity has no more relation to empirical reality than a musician's strumming *until* the nature of the correspondence between symbol and operation[9] has been established. Thus the physicist does not prove something about the physical world when he solves the differential equation for the falling body[10] unless and until he operationally identifies the meaning of each symbol of the solution. In fact more than one *formal* solution is possible

[8] Quoted by R. Carnap, *Philos. Sci.*, 1, 5–19 (1934).

[9] By *operation* is meant throughout this paper the physical, concrete operations which are differential reactions on the part of living organisms. These operations are in no sense imaginary or 'mental'—unless, of course, 'mental' is operationally defined. The mathematician also speaks of operations, but he refers to the manipulation of symbols according to rule, which he carries out on the *formal* level.

[10] P. W. Bridgman has discussed the problem of making the formal 'model' fit the observations. See his On the nature and limitations of cosmical inquiries, *Sci. Monthly*, 37, 385–397 (1933).

in this case, but the physicist rejects as meaningless the solution involving negative velocity because it corresponds to nothing he can identify in the physical world. Similarly, the logical positivists insist that we reject as 'meaningless' all of the word arrays of metaphysics whose terms have no empirical denotation. Purely formal statements have form but are without content and are 'meaningless;' empirical statements likewise have form, but they are operationally verifiable and are 'meaningful.'

The psychologist would agree that the distinction must be carefully made between operationally founded and 'meaningless' statements, but whether he would thereby care to insist that the activity which leads men to make 'meaningless' statements should be arrested is another question. He thinks rather that it would be a dull world to live in if we excluded the 'formalizers,' for that would deprive us of the mathematician, the logician, the metaphysician, the poet, the theologian and the other manipulators of symbols. The logician and mathematician are particularly useful to him, because they develop the rules—the axioms, postulates and definitions—governing the use of the symbols upon which we rely for communication and which therefore determine the conventions that we follow. Because of their concern with the 'tools of thought' it would be plausible to regard logic and mathematics as the propaedeutic science, except 1) that logic and mathematics are not sciences in the empirical sense, and 2) that the experimenter-regress (*vide supra*) enables the psychologist to step back a stage and study the laws governing the behavior of the logician and the mathematician themselves. Needless to say, however, in this respect psychology has made meager progress toward filling its rôle of propaedeutic science. It pleads inexperience before such a complicated and difficult task.

Nevertheless, the perspective we have achieved in regarding formal statements as behavioral patterns, which need supplementary operations to make them empirically meaningful, enables us better to understand the nature of that difficult item, the hypothesis. An hypothesis is an array of symbols ordered after syntactical rules, the result of someone's activity as it were, but also an array which is without complete operational meaning.

However, the symbols may be given denotative power by subsequent observations, a point at which the hypothesis becomes an empirical statement. All prestatements, as well as hypotheses, represent behavior according to rule, i.e., the manipulation of symbols. The important thing about hypotheses is not, however, that they issue from a particular type of behavior and are empirically meaningless, but that they have important psychological effects on us. For certainly it is the hypothesis, the belief that such and such is the case before we have seen it, that accounts for most of the activities of scientists. A good hypothesis has a heuristic value which speeds men on to important discoveries, and which to a large extent determines the fruitfulness or sterility of an investigation.

Consequently operationism, which has been accused of being hypercritical and conservative to the point of defeat because it would purge science of the unoperational and the 'meaningless,' must answer that it does not intend to abolish the 'meaningless,' but merely to label it and to keep an eye on it so that it will not get mixed up with operationally valid concepts and thereby generate what Carnap calls pseudo-problems. Above all we need hypotheses just as we need mathematics; we need speculation, more and more daring, for our spirits are not fed and our imaginations are not fired by the recitation of dull, hard facts. Our present body of operationally valid knowledge is merely the starting place for new flights which will bring back increased knowledge—providing, of course, that we keep the landing field clear of unoperational obstructions.

Finally there is the problem of the emotional effects of 'meaningless' formal statements. Assertions about the acuity of the all-seeing eye of God are 'meaningless' by the operational criteria, yet many will insist that scriptural pronouncements have meaning to them personally. In this case something is meant by *meaning* different from the operational definition which we have adopted. Such statements are 'meaningless' in that no operations are prescribed for their verification, and the apparent meaningfulness to certain persons issues from the fact that emotional experiences and modifications of behavior result from hearing them. To call

metaphysical statements 'meaningless' is in no way to detract from their importance as forces in molding civilization. Such a classification merely emphasizes the fact that the justification for metaphysical statements is not to be sought in their ability to convey information, but must be found in their power, as word arrays, to modify attitudes and action. Music has precisely the same validation. Psychology regards both metaphysics and music as stimuli.

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Evolution and the Rise of the Scientific Spirit in America

BY

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TEN years ago the civilized world was shocked out of an unwarranted confidence in the victory of science over superstition by the news that Tennessee had outlawed the teaching of man's evolutionary origin. Within the next three years both Mississippi and Arkansas joined Tennessee in defense of Biblical truth against the scepticism of science. The furor raised by the dramatic clashes between William Jennings Bryan and Clarence Darrow at the Scopes Trial in Dayton, Tennessee, has now become a faded memory. The struggle between Fundamentalists and Modernists has died down, though the embers still smoulder; and few ever think of the issues then raised, now that war and fascism threaten civilization.

Yet the crucial principle of the controversy over evolution cannot be forgotten; it still lives, in a different form, in the issues that face us now. Shall Reason or Prejudice be the arbiter of our destiny? The answer that will be given to that question depends in part on the extent to which the scientific spirit has become dominant in society. What rôle Evolution, as a revelation of science, played in the creation of the Scientific Temper in America has never been critically evaluated; few have dared to study at first hand how the impact of the theory of evolution upon the Victorian Age brought about a cataclysmic religious and scientific upheaval and readjustment.

Change in human affairs is sometimes gradual and imperceptibly cumulative; but sometimes swift, sudden, catastrophic. If men are plastic, eager to learn, and strong in reason, civilization advances; if not, civilization declines or perishes. Now the most significant effect of Darwin's discovery was, not the triumph of certain specific scientific theories, but a revolutionary change in the very process by which men arrived at their convictions. To throw overboard the sanctions of authority, ancient prejudices, and the hallowed rationalizations of *a priori* philosophy, and to embrace the method of science was a far greater achievement than the discrediting of an outmoded cosmology and the shocking incorporation of man into the animal kingdom.

But many who discarded old theological dogmas and accepted the popularized (and distorted) versions of evolution only exchanged one mythology for another. One name, however, stands out as the pre-eminent exponent of intellectual honesty and scientific method in that age of intellectual confusion and emotional stress: Chauncey Wright. Now unknown and unhonored, this philosopher was the truest champion of evolution and science; unlike John Fiske and Asa Gray, he did not make a new religion of evolution or force science to be the handmaiden of theology. He was wise enough to see that "to live by science requires intelligence and faith, but not to live by it is folly." Only when the contribution of Chauncey Wright is placed against the background of his age, can the rise of the scientific spirit in America be seen in proper perspective.

On November 11th, 1859, Charles Darwin sent copies of his latest work; *The Origin of Species*, to two men in America—Louis Agassiz and Asa Gray. Asa Gray was the greatest botanist in America; Louis Agassiz, his colleague at Harvard, the greatest zoologist. Gray, a personal friend and correspondent of Darwin's, had already been won over to his theories. But Agassiz, the brilliant Swiss naturalist, noted as the protégé of Alexander von Humboldt and Cuvier, could not abandon the philosophy of a life-time so easily. Cuvier, his master, fifty years before had ridiculed Lamarck's evolutionary theory into obscurity and had popularized a theory that the species of different geologic epochs

had been created after successive cataclysms. Agassiz, in his famous *Essay on Classification* published in 1857, had elaborated on this theme. He declared that species were thoughts of God and immutable and that the diversity of species was the result of repeated interventions on the part of the Creator. A theory so firmly based on the method of intuition would not yield at once to a new scientific doctrine that seemed charged with materialism. Agassiz threw the weight of his immense influence as the foremost zoologist and popular lecturer in America against Darwin's theory.

Soon after an American edition of Darwin's book appeared in January, 1860, an irrepressible conflict of ideas on science and religion began to parallel the struggle over slavery and secession. Heated debates took place at the Boston Society of Natural History and the American Academy of Arts and Sciences. In the spring and fall of 1860, magazines like the *American Journal of Science*, the *North American Review*, the *Christian Examiner*, the *Atlantic Monthly*, the *Methodist Quarterly Review*, and the *American Theological Review* carried long and lively articles attacking or defending this latest of heresies.

To one sufficiently detached by time or philosophy, the attacks on Darwin's theory—even by so great a scientist as Agassiz—are impressive, not as scientific arguments, but as beautiful rationalizations of religious faith in an obsolete metaphysics. True, the scientific evidence bulked large in the discussions, and some sound criticisms were made, but these were the pretexts, not the causes, for rejection. As C. S. Peirce pointed out, most, if not all, reasoning on vitally important topics consists in finding reasons for believing what the heart desires.

Yet intellectual honesty requires that justice be done to some penetrating points made by Agassiz, the foremost opponent of evolution. He stressed, for instance, the fact that not all primitive organisms are simple, and that the most perfect organs are not the result of gradual development.

Francis Bowen, Professor of Moral Philosophy and Natural Theology at Harvard, deserves mention as being next to Agassiz the keenest enemy of evolution. His scorn some fifteen years before for the evolutionary theory of Robert Chamber's *Vestiges*

of the Natural History of Creation as a "pure hypothesis which might be summarily dismissed into the region of cloud-land and dreams, where it had its origin" was now visited upon the "ingenious and captivating" theory of Darwin's. He alone called attention to Darwin's evasion of the origin of the human species and asserted Darwin would have to find the means of bridging over, by imperceptibly fine gradations, "the immense gap which now separates man from the animals most nearly allied to him."

Bowen also was the first to declare evolution incompatible with the doctrine of final causes, and a negation of design or purpose in the animate or organic world. In this opinion he was upheld by President Goodwin of Trinity College, Hartford, Conn., who wrote in the *American Theological Review* for May, 1860: "Mr. Darwin does not expressly attack Christianity or Theism. He scarcely notices them at all. But a theory of origins or ends that ignores Theism altogether, is as truly its enemy as one which attacks it openly in front, and must be treated by the friends of Theism accordingly."

The lengths to which friends of Theism would go in defending the deeply cherished proofs of natural theology for the existence of God against the atheistic doctrine of evolution is shown in the fervent assertion by J. A. Lowell in the *Christian Examiner* for May, 1860 that miracles "have never presented to our mind any metaphysical difficulty. The Power that could enact and sustain, must, in our apprehension, of necessity be equally able to suspend or alter, the laws of nature."

Against such sublime faith in orthodoxy and frequent confusion between vituperation and refutation of evolution, rare courage and ability were needed. These were supplied in ample measure first and foremost by Asa Gray, who was an army in himself, secondly by William B. Rogers—an able geologist, and by Professor Theophilus Parsons of Harvard Law School. In public debate and magazine articles they vigorously met their opponents point by point and proved their superiority in sound logic. They admitted that Darwin's theories did not adequately explain all phases of the processes of evolution, but they insisted that his evidence as to the fact of evolution was overwhelming and that

Natural Selection was a necessary, although not a sufficient cause of evolution.

Professor Parsons, "almost if not quite a man of genius," according to Mr. Justice Holmes, was one of the first throughout the world to advance a mutation theory of evolution to account for the gap between species in the geologic record (Proc. American Academy Arts and Sciences, April 10, 1860).

It is also only just to Parsons' memory to point out that he stood next to Asa Gray in repelling the attacks upon the atheistic character of evolution and argued cogently that rational religion need not fear the revelations of science. He alone in America at that time, so far as I can discover, dared to declare that since the Bible was no authority on the question of man's origin, neither reason nor religion would be shocked if science considered man descended from the Simiae. Surely this was an advance upon even the bold rationalism of Thomas Cooper, who had so ardently taken Benjamin Silliman, the Yale Geologist, to task in 1829 for distorting geology to prove Biblical assertions about the Flood. The revolt of American geologists in the 1830's against the strict literal interpretation of the Bible as laid down by such prophets as Moses Stuart of Andover Theological Seminary was now bearing fruit.

Unfortunately for civilization, the progress made by Asa Gray, Parsons, and Rogers in breaking down resistance to evolution was halted by man's concern over the fortunes of war. The appeal to arms in the War for Southern Independence so overshadowed all appeals to reason in science and religion that a diligent search through some twenty scientific, religious and popular magazines reveals but four articles on evolution from 1861 to 1865. Only a few scientists found time or strength to shut out the news of daily battle and consider the struggle for existence and Natural Selection *sub specie aeternitatis*.

Asa Gray, at the suggestion of Charles Darwin, had three essays he had written for the *Atlantic Monthly* in July, August and October 1860 on *Natural Selection not inconsistent with Natural Theology* reprinted as a pamphlet in 1861. Darwin, although not in sympathy with this point of view, believed it was of much value

in lessening opposition and making converts to evolution and showed his high opinion of it by inserting a special notice of it in a most prominent place in the third edition of the *Origin of Species*.

But Louis Agassiz still clung to his opinion that Darwin's theory was "a scientific mistake, untrue in its facts, unscientific in its method, and mischievous in its tendency." In the preface to a volume on *Methods of Study in Natural History* published in 1863, he wrote with passionate eloquence against the evolutionary theory and said:

> I confess that there seems to me to be a repulsive poverty in this explanation that is contradicted by the intellectual grandeur of the universe; the resources of the Deity cannot be so meager, that in order to create a human being endowed with reason, he must change a monkey into a man. . . .

Realizing this to be only a personal opinion, Agassiz went on to speak in the name of science:

> I insist that this theory is opposed to the processes of Nature, as far as we have been able to apprehend them, that it is contradicted by the facts of Embryology and Paleontology. . . .

Against such ancient prejudice masquerading as scientific fact, Huxley's short but explosive book: *Evidence as to Man's Place in Nature*, was an effective answer. But James Dwight Dana shared Agassiz's intuitions and wrote in his review of Huxley for the *American Journal of Science*, May 1863, that "with regard to Man and the Man-apes, no evidence has been pointed out, derived from Man, or the Apes, proving either the fact, or the probability, or the possibility of a common origin." A critic of Huxley in the *North American Review* for July 1864, admitted that evolution might be of some use as a provisional hypothesis in comparative anatomy, but declared that if evolution were admitted with regard to the physical structure of the human being, something he heartily deprecated, "it could not reach the realm of reason, conscience, and will, it could not cast a ray of doubt on our Divine sonship and immortal birthright on the spiritual side. . . ."

'Eternal truth bears eternal repetition,' but what passes as eternal truth usually is uncritical assumption and hasty generali-

zation erected into unquestionable first principles. Slowly doubt spread and undermined dogmatic faith. Typical of the process of faith and final conversion that many scientists underwent was the experience of Jeffries Wyman, the brilliant comparative anatomist. In the *American Journal of Science* for September 1863 he remarked in passing that scientists had to choose between supernatural creation or evolution. Although he suspended judgment for a time, he finally made the scientific choice.

Even students of Agassiz began to shake off the spell of his personality and free themselves from the method of authority. Men like Nathaniel S. Shaler read books by Darwin and others on evolution and debated the theory in private (it would never do for the faithful to be caught in the careful study of a heresy). They dared to press their master for some conception of how a species first appeared and were no longer satisfied with his mystical answer that a species was a thought of God.

The deep silence of the press on evolution was broken as the conflict over slavery drew to its tragic close. An obscure essayist in the *Evangelical Quarterly Review* for January 1865 upheld the immutability of species and damned evolution as inconsistent with the biblical doctrine of Providence and as an attempt "to substitute a power of nature for the personal, intelligent, and overruling God whom Christians worship."

But that very month the *North American Review* carried the most effective refutation of religious dogmatism on science that could have been written: an essay on *Natural Theology as a Positive Science* by Chauncey Wright, who was later to prove the most brilliant defender of evolution in America. He declared:

> That there is a fundamental distinction between the natures of scientific and religious ideas ought never to be doubted; but that contradiction can arise, except between religious and superstitious ideas, ought not for a moment to be admitted. . . . If the teachings of natural theology are liable to be refuted or corrected by progress in knowledge, it is legitimate to suppose, not that science is irreligious, but that these teachings are superstitious; and whatever evils result from the discoveries of science are attributable to the rashness of the theologian, and not to the supposed irreligious tendencies of science.

In accord with Wright's philosophy, an anonymous reviewer of Huxley's *Lectures on the Elements of Comparative Anatomy*, wrote in the same issue of the *North American Review* that evolution seemed destined to prevail and suggested that perhaps "by accustoming our imagination to contemplate the possibility of our ape descent now and then, as a precautionary measure, the dire prospect, should it ever really burst upon us, will appear shorn of some of its novel horrors, and our humanity appear no less worthy than before."

Soon after the publication of these three interesting discussions, the War ended, but not the sectional antagonisms. During the critical years of Reconstruction philosophic detachment became impossible for all but a few, and little of great moment appeared on evolution until 1868. Yet that little indicates that the forces of evolution were gaining ground against the opposition.

Leo Lesquereux, the distinguished paleo-botanist, wrote Darwin towards the end of 1865 that after repeated readings of Darwin's book, he had become a convert, but to Darwin's astonishment, chiefly because the *Origin of Species* made the Birth of Christ and Redemption by Grace more easily intelligible to him. That same winter J. P. Lesley lectured on *Man's Origin and Destiny* before the Lowell Institute in Boston and championed evolution with much enthusiasm, force, and unscientific dogmatism. The next year Charles J. Sprague contributed a defense of the Darwinian theory to the *Atlantic Monthly*, and in August 1867 Professor J. S. Newberry of Columbia, a friend of Agassiz's and President of the American Association for the Advancement of Science that year, came out as a supporter of evolution, although he stressed the need for more research to clarify the origin of life and the mechanism of evolution.

This encouraging trend received a definite impetus in 1868. Darwin's monumental work: *Variation of Animals and Plants under Domestication*, published in January, met with high praise from the leading periodicals and buttressed the evidence of evolution. In April, a writer for the *Southern Review* defended evolution as scientifically sound, though still not adequately proved, and as not destructive of belief in God. Francis E. Abbot, a

penetrating thinker now unjustly neglected, wrote in the *North American Review* for October a strong attack on the hypothesis of special creations as "the delusive substitute of words for thoughts" and declared evolution to be the only intelligible hypothesis.

A new and powerful defender of evolution against the charges of atheism was James McCosh, the noted Scotch theologian who came to America in 1868 to become President of the College of New Jersey (now Princeton). At Harvard Charles W. Eliot became President in 1869 and inaugurated a reign of liberalism by having John Fiske deliver a series of lectures of evolution and positivism. His audiences were small, but the lectures received wide circulation by being published in full in the *New York World.* A storm of orthodox protest against this new infidelity fell upon Fiske, Eliot, and the *New York World,* but Eliot was not the man to be daunted by public fury and reengaged Fiske for another series of lectures on evolution to be given in 1871.

Another champion of religious liberalism was James Freeman Clarke, the great Unitarian minister of Boston. In 1870 he boldly declared in his volume *Steps of Belief* that evolution had not, in itself, the slightest atheistic tendency.

Nevertheless, the progress of evolution during these years was not free from opposition. Articles against evolution appeared in the *Christian Examiner* for January 1866 and *Harper's New Monthly Magazine* for December 1867. Louis Agassiz still warred against evolution with his old fervor. In a lecture before the National Academy of Science in 1866 and in a book on Brazil published in 1868, he presented new evidence that he felt sure would kill what he called "this mania" for evolution; but he was doomed to disappointment.

The gathering strength of the evolutionists brought new allies to Agassiz. Horace Bushnell wrote a vehement criticism of evolution in *Putnam's Magazine* for March 1868 and pontifically declared that if evolution were true, then both science and religion were impossible. Parke Godwin at a dinner in honor of Charles Dickens in April 1868 made fun of the new doctrine of evolution, which, as he put it, announced that long ago a lot of dust began

twisting and twisting until it got twisted into Parthenons and Shakesperes. This revolt against science was continued in equally scornful essays in the *Baptist Quarterly*, the *Biblical Repertory*, the *Catholic World*, and the *Congregational Review* from 1868 to 1870.

But a new phase of the struggle over evolution opened with the publication of Darwin's *Descent of Man* in the Spring of 1871. All the objections to evolution that appeared before 1871, no matter how impassioned or widespread, were mild and insignificant in comparison with the hurricane of outraged feeling and religious indignation aroused by this book. Edward L. Youmans wrote Herbert Spencer on April 21st.:

> Things are going here furiously. I have never known anything like it. Ten thousand *Descent of Man* have been printed, and I guess they are nearly all gone. Five or six thousand of [Huxley's] *Lay Sermons* have been printed . . . the progress of liberal thought is remarkable. Everybody is asking for explanation. The clergy are in a flutter.

We can understand the intense excitement and interest in 1871 only when we remember that Darwin had very cautiously and carefully avoided all discussion of man's origin in *The Origin of Species* in order to concentrate attention first on the general problem. True, he had promised "light would be thrown on the origin of man and his history," but despite Huxley's explicit exposition on *Man's Place in Nature* in 1863, comparatively few had worried about man's animal origin.

This explains why a liberal in religion like Joseph P. Thompson, as late as 1870, could say in his book: *Man in Genesis and in Geology*, that "in the present stage of science, I may safely lay down the postulate, that Man had a beginning, and that Nature is not proved adequate to have caused that beginning. He appeared upon the plane of nature with an organism that Nature fails to account for, and with powers for which Nature furnishes no precedents." C. L. Brace, a champion of evolution, could attack certain German scientists for believing that men were descended from apes and denying that man's origin and mind required special intervention by God. Even Alfred Russel Wal-

lace, the co-discoverer with Darwin of natural selection, felt that miracles were needed to explain man's consciousness and moral sense.

Hence, it is not astonishing that practically the entire religious press in 1871 united in denouncing Darwin's most terrible of libels against man's divine origin. The *Methodist Quarterly Review*, the *Congregational Review*, the *American Presbyterian Review*, and the *Christian Quarterly* affirmed with great vigor and much vehemence that man belonged to a separate kingdom from all the rest of creation and had been specially blest by God with consciousness and morality. Similar views appeared in non-sectarian magazines like the *Eclectic*, *Littel's Living Age*, the *National Quarterly Review*, and the *Overland Monthly*.

What anguish and turmoil of spirit advanced liberals in theology underwent is illustrated by the case of James McCosh. He felt and preached that no conflict existed between evolution and religion and declared in a noted series of lectures on *Christianity and Positivism* in 1871 that evolution, "properly understood," invoked supernatural intervention to account for life, intelligence, and morality. He lacked the courage to extend the logic of his half-way liberalism to man. He shrank with horror from the picture drawn by Darwin of man descending from a hairy quadruped, and with the desperate courage of his confusion used logic most illogically to prove that Scriptures were a weightier authority than Science on the origin of man.

Amazing as McCosh's use of the method of authority was, his irrationalism could not compare in boldness or assurance with the *ex cathedra* dicta of Charles Hodge, Professor of Theology at Princeton and valiant champion of rigid, uncompromising orthodoxy. Strong in conceit, terrible in scorn, Hodge used every method other than that of science to show that Darwin was thoroughly atheistic and therefore could not be scientifically sound. In three noted works that he published between 1871 and 1875 he spurned the mere naturalist, "the man devoted so exclusively to the study of nature as to believe in nothing but natural causes," and proclaimed with an enviable confidence in his own infalli-

bility: "God has revealed his existence and his government of the world so clearly and authoritatively that any philosophical or scientific speculations inconsistent with those truths are like cobwebs in the track of a tornado. They offer no sensible resistance."

Certitude is not the test of certainty, as Mr. Justice Holmes has said. Yet many were so swayed by emotion and blinded by prejudice as to confuse the two and jump to the unwarranted conclusion that evolution was incompatible with true spirituality. The *Southern Review* for January 1872 featured an essay on *Modern Atheism*, in which the author exclaimed with great emotional intensity:

> Is man, in other words, merely a monkey, minus the tail, or is he in his most amorphous, monstrous condition, merely a man minus religion and faith—minus all that is greatest and most Godlike in human nature? . . . if in this life only we have hope, then are we of all men, and of all animals, the most miserable. Tell us not then, O ye mighty prophets of science! that the soul itself is merely a "mode of motion," a bubble blown upon the bosom of a shoreless eternity of life, . . . and then (to) pass away, to make room for other bubbles.

As noted a scientist, educator, and liberal as President Barnard of Columbia College declared in 1873 that if spontaneous generation, organic evolution, and the correlation of mental and physical forces were true, then the existence of God and the immortality of the soul were impossible. So terrible a prospect was more than he could endure; he renounced without shame his intellectual integrity to preserve his dream of heaven:

> Much as I love truth in the abstract I love my sense of immortality still more; and if the final outcome of all the boasted discoveries of modern science is to disclose to men that they are more evanescent than the shadow of the swallow's wing upon the lake . . . if this, after all, is the best that science can give me, give me then, I pray, no more science. I will live on in my simple ignorance, as my fathers did before me; and when I shall at length be sent to my final repose, let me . . . lie down to pleasant, even though they may be deceitful dreams.

Extraordinary as Barnard's renunciation of science and his advocacy of the Will to Believe was, his position was not unique.

The presidents of such leading colleges as Yale, Princeton, Williams, Amherst, Brown, Hamilton, Lafayette, and Rochester denied that they taught "such unverified hypotheses" as the evolution of man from irrational animals. As President Seelye of Amherst put it, they did not "teach groundless guesses for ascertained truths of science."

At a time when the higher Biblical criticism and the science of comparative religion were weakening the traditional dogmatic beliefs, the impetus given to a naturalistic philosophy by evolution stirred the opponents of modern science to white heat. The 70's and 80's brought a tragic wave of academic persecution. The first martyr in the cause of evolution was Alexander Winchell, Professor of Geology at Vanderbilt University, which was controlled by the Southern Methodists. Upon Winchell's expulsion in 1878, the Tennessee Methodist Conference commented as follows:

> The unthinking masses have been sadly deluded. But our university alone has had the courage to lay its young but vigorous hands upon the mane of untamed Speculation and say, "We will have no more of this." Science we want, no crude, undigested theories for the sons of our patrons—science we must have, science we intend to have, but we want only science clearly demonstrated. . . .

The next year Professor C. H. Toy of the Southern Baptist Seminary at Louisville, Kentucky, resigned at request because he used modern science in interpreting the Old Testament. In 1884 Professor James Woodrow, Woodrow Wilson's uncle, paid the price for his courageous defense of evolution at the Presbyterian Theological Seminary at Columbia, South Carolina, by being forced from his position. In 1891 Professor Alexander at the University of South Carolina dared to voice doubts concerning the divinity of Christ and lost his position in consequence. Two years later Professor Briggs of Union Theological Seminary of New York City was tried by the General Presbyterian Assembly for heresy and was expelled from the ministry. Economic determinists might well reflect on the fact that property rights are not the only vested interests that inspire persecution; it is the deeply-

rooted love of illusion that makes the pursuit of truth so radical a test of courage.

The irony of this spiritual conflict and irrational persecution is that few understood how needless the struggle was. Surely the best part of religion, if not its essence, is its poetic interpretation of moral experience. Science cannot conflict with rational religion, which is based upon the moral adequacy of naturalism. Such a religion recognizes that faith in the supernatural and a future life is a desperate wager made by men eager to be deceived by a play on words; the supernatural, in the last analysis, is an idealization of man's natural situation and a promise to satisfy his earthly interests. But learning, as Santayana has said, does not liberate men from superstition when their souls are cowed or perplexed. They defend supernatural systems although they have only natural interests at heart because they lack the courage or candour "to distinguish the edge of truth from the might of imagination" and "to conceive other moulds for morality and happiness than those to which a respectable tradition has accustomed them."

The tenacity, authoritarianism, and mystical intuition relied upon to support exploded myths refute the facile identification of progress and evolution. No greater obstacle in the advancement of civilization exists than the tendency of men to distort discussions on matters of vital import into apologetics; even professional scientists and philosophers became so absorbed in defending some vested illusion or eloquent idea that they do not welcome truth, but seek victory and the dispelling of their own doubts. Their failure to see the ultimate futility of all romantic self-deception and the classic need for self-understanding if peace with the world and oneself is to be attained, harms not only themselves, but, what is even more deplorable, those who have the strength to envisage the truth and rebel against myth posing as science. Those in revolt against tradition usually pay a terrible tax to the errors of the past: they are led to stress the sharp contrasts between their new philosophy and that in authority, and hence parallel the old false patterns and emphases. Only a very great and generous mind can champion truth and point out the inval-

idity of established tenets without being carried away by a crusading zeal into injustice to some sound insight underlying the more patent absurdities.

That rare union of vision and balance distinguished Chauncey Wright and made all he wrote the enduring foundation of rational naturalism in America. His name is now unknown to all but a few; yet he was the philosophic master of three American immortals: Charles Sanders Peirce, the greatest logician America has produced; William James, its greatest psychologist, and Justice Holmes, its greatest jurist. Wright's merits as a champion of evolution have been unjustly obscured by the éclat of John Fiske's fame. Future historians, however, will redress the balance; Wright will then come into his own as the foremost philosophic exponent of evolution in the United States and the founder of rational naturalism, pragmatism, and pluralism. His *Philosophic Discussions* (1877) and *Letters* (1878) will then take their place among the philosophic classics of America.

For the ten years after 1865, and particularly between 1870 and 1875, Wright towered above all his American contemporaries as the philosophic champion of evolutionary naturalism. The essays he wrote for the *North American Review* on *The Limits of Natural Selection* (October, 1870), *The Genesis of Species* (July, 1871), *Evolution by Natural Selection* (July, 1872), and the *Evolution of Self-Consciousness* (April, 1873) were of such extraordinary brilliance, originality and force that they attracted international attention. Darwin, who had been seriously worried by a powerful attack on his theory of Natural Selection by St. George Mivart, was so impressed by Wright's refutation of Mivart in the essay on the *Genesis of Species* that he had it reprinted at his own expense as a separate pamphlet for distribution in England.

In these essays, his book reviews for the *Nation*, and his private letters, Wright brought a most masterly use of the scientific method to lay bare all the imposing fallacies underlying the opposition to evolution and naturalism, show that rational religion could have no conflict with science, prove that the emergence of self-consciousness and morality were capable of explanation as natural events, and refute all the baseless fears that hope for

humanity and reverence for spiritual excellence would disappear once man's animal origin was recognized. He regarded it as most unfortunate that the prepossessions of religious sentiments in favor of antiquated metaphysical theories should make the progress of science always seem like an indignity to religion, or a detraction from what is held as most sacred; yet the responsibility for this, he felt, belonged neither to the progress of science nor to true religious sentiment, but a false conservatism, and irrational respect for the ideas and motives of an unscientific philosophy. He realized men's love of pedigrees and their attribution of moral dignity to lofty origins and therefore exposed the fallacy of confusing the two distinct categories of moral worth and causal dependence, value and history. Men were what they were, whether descended from gods or the ancestors of monkeys. In fact, if the latter theory were true, humanity had cause for hope since men had made some progress.

The sanity that prevented Wright from turning history into mythology and science into mythic cosmology led him to develop the humanistic implications of naturalism. Convinced that most, if not all, of the puzzles of metaphysics might be reduced to unconscious puns, or unseen ambiguities in terms, he exposed the emptiness of supernaturalism and other-worldliness by showing that all the ends of life are within the sphere of life and are, in the last analysis, to be found in the preservation, continuance, and increase of life itself. Questions concerning the uses of life he suggested could be solved by asking: To what ascertainable phase of life is this or that other phase of life valuable or serviceable? All forms of movement in life have some value in themselves; yet life in the widest sense is neither good nor evil, but the theatre of possible goods and evils. Hence, if any particular way of life becomes unbearable, not suicide, but the rational reorganization of the ends of life, is the solution.

Here was the basis for the rational ethics that American society needed most in the moral chaos of the euphemistically-called reconstruction period. But the death of Wright in 1875, while still in his prime, left no peer to develop the system of naturalistic ethics that he had sketched. Yet his influence lived on among a

few choice spirits. His work had shown that to be a great thinker one must have a heroic soul, that no man could boast of being civilized until he had questioned his own first principles, and that human life could be brought to perfection only when illuminated by intelligence and based on a morality frankly relative to man's nature and freed from the bonds of the pretentious moral absolutism of a supernatural creed.

So profound and noble a philosophy was condemned by its very excellence from becoming the dominant force in American thought at that time. Wright's evolutionary naturalism was the achievement of a great mind; to be understood it required minds equally great and courageous in applying scientific method to the most dearly held beliefs. The sacrifice of all illusions on the altar of truth was a price that no other champion of evolution in America was willing or able to pay. Even Benjamin Peirce, the foremost American mathematician of the nineteenth century, surrendered reason to faith and though he acknowledged the truth of evolution, said in 1879 that science was erecting the brute and unconscious force of evolution into an original divine power and honoring it as a god. In his eyes, Nature was "God's messenger," "the poem of an infinite imagination, signifying Immortality," and evolution "but the mode in which he is present on whom mortal cannot look with physical eyes and live."

A similar philosophy animated John Fiske, the great apostle of Herbert Spencer in America. Incomparably inferior to Wright in logical acumen, scientific training, and philosophic vision, Fiske nevertheless attained a national popularity and success that Wright never hoped for or dreamed of. Blessed with a lively and vivid style, a remarkable breadth, if not, depth, of scholarship, and a contagious moral enthusiam, he impressed his generation as a very great man and wielded immense influence. From 1869 on he crusaded for evolution, and after 1875 succeeded Wright as its most noted defender. His *Outlines of Cosmic Philosophy*, published in 1874, ran through sixteen editions and helped to make evolution the fashionable creed of the 1890's. Yet the victory for science was a hollow one. Fiske and his associates: Asa Gray, Joseph Le Conte, Henry Ward Beecher, and Lyman

Abbott, won a wide currency for evolution by denaturalizing it into a new mythology.

Darwin had conceived of evolution in purely naturalistic terms; all his work implicitly denied the Aristotlian doctrine of evolution by ideal attraction and was a triumph for naturalism as the basis of life and morals. But Herbert Spencer was seduced by the dramatic charm and glamour of evolution and converted good science into bad poetry. He identified evolution with progress, with betterment—a tribute to his humanitarian sympatheties, but completely unwarranted by sober science. He changed a biologic truism: the survival of the fittest, into an unsound moral dogma that enabled many to rationalize their indifference to social injustice, their insensibility to human ideals, and their support of vested interests under pretense of respect for historic necessity and the dictates of science.

Comforting as Spencer's vision of a steadily improving universe was, his cold agnosticism could not satisfy the emotional needs of many. Fiske, speaking in the name of science, most unscientifically abandoned the logical rigor that would have led to an evolutionary naturalism, and promulgated a cosmic theism that made man's spiritual development the goal of the whole evolutionary process. This optimistic mythology appealed to many and became the religious dogma of the day. Men were given a cosmic importance and assurance that made them feel: This is the best of all possible worlds. Only a sceptic like F. H. Bradley could add: "and everything in it is a necessary evil."

Fiske's fall from naturalism was condemned by few. His use of the method of intuition to justify his Will to Believe was confused by the multitude with the method of science because he based his cosmic myth on the results of science. They did not realize how unscientific a synthesis of science might be that was prompted by aesthetic and religious motives and were not too critical of philosophies that answered their desires.

Only in the early part of this century did a decided revolt develop against the last defense of the Genteel Tradition expressed in the "Will to Believe" movement. Naturalism received a new birth when Santayana, Dewey, Singer, Morris R. Cohen and

others repudiated all apologetics and asserted the supreme claim of reason in judging all cherished beliefs. To-day, for various social and economic reasons, we are witnessing in philosophy and science an unfortunate return to mysticism and supernaturalism. The defenders of naturalism in philosophy are facing a situation very similar to that which Chauncey Wright encountered in the 1870's. The progress of civilization in America will depend on a reassertion of scientific method as the only sound means of attaining a solid basis for security and happiness. All other methods are a snare and a delusion.

Columbia University

DISCUSSION (CORRESPONDENCE)

In this section we shall publish brief communications commenting on published papers or bringing up special points of interest which can be discussed by correspondence.

THE LAW OF TRANSITIVITY

Dear Sir,

It may have a methodological interest for those occupied with the algebra of propositions to give a simple proof that the law of transitivity fails in any logic in which all modal distinctions are recognized. Thus,

Definition: $|p| = (p \angle o)'$ (p does not imply zero)

Assume 1. $p \angle ||p|'|'$ (Brouwer's law)

$$p \angle ||p|'|'.\quad ||p|'|' \angle o.\quad \angle.\quad p \angle o$$

from which we get, suppressing the first premise,

$$|||p|'|'|' \angle |p|'$$

Now substitute $p = |p|'$ in 1, then

$$|p|' \angle |||p|'|'|'$$

so that $|p|' = |||p|'|'|'$ and one modal distinction is wiped out.

Assume 2. $||p|'|' \angle p$

$$||p|'|' \angle p.\quad p \angle o.\quad \angle.\quad ||p|'|' \angle o$$

from which we get, suppressing the first premise,

$$|p|' \angle |||p|'|'|'$$

Now substitute $p = |p|'$ in 2, then

$$|||p|'|'|' \angle |p|'$$

so that $|p|' = |||p|'|'|'$

The so-called two-valued logic, which recognizes no modal distinctions at all, may be said to possess a minimum generality. It is not surprising, therefore, that it should find itself helpless in the face of any paradox whose solution depends on making the proper modal distinctions. Nor is it surprising that certain simple laws, like the law of transitivity, should fail in a logic that is perfectly general, but become true in the very special case developed in *Principia Mathematica*.

H. B. Smith.

University of Pennsylvania.

INDUCTION AND PROBABILITY

Dear Sir,

It is only now that the most interesting paper of H. Feigl in Vol. I, No. 1, on "The Logical Character of the Principle of Induction," has come into my hands. He writes: "It is particularly gratifying to me that Prof. Reichenbach, after an Odyssey of attempts to found induction on probability has finally recognised our (Viennese) criticisms and is joining us now in the pragmatic view of inductive generalisation." Well, I am very glad to learn that my theory corresponds to the Vienna point of view, a fact which I never found mentioned by leading members of the group. But if this is true, it can only be the case because the Vienna circle changed its conception,—not I. Though a believer in the relativity of motion in physics, I cannot apply this relativity here and must distinguish between the statement that the Vienna group has approached my standpoint and the one, that I have approached the Vienna standpoint. That it is only the first which is true seems to me clear from the following facts:

1) The Vienna circle up till now has insisted on the demand that every proposition be verifiable as true or false.
2) The Vienna circle called the principle of induction a rule for action and not for knowledge.
3) The Vienna circle maintained the problem of the justification of induction to be a pseudoproblem.

On the other hand, I have maintained for many years the following views:

1) The demand of absolute verifiability must be dropped for all synthetic propositions, because else we ought to drop the propositions of science altogether. Instead of that a continuous scale of probability is to be introduced.
2) The principle of induction is not only a rule of action but also a rule which we must make use of to get propositions concerning the future.
3) The justification of the principle of induction is no pseudoproblem, but the most important problem of modern epistemology, without the solution of which we are not entitled to call our logic empiricism, a refutation of the synthetical a priori.

Now it is true, that I had to pass a long Odyssey of theoretical attempts before I was able to solve the problem of the third statement, and to develop the logic of probability demanded in the first one, while always maintaining the second one. But I observe a continuously

progressing line in this Odyssey, and I don't find, now when I am at the end of the voyage, that any one has had a shorter way to my result. What I find is that those who came to results somewhat similar to mine, miss certain fundamental components of my solution, above all, the close connection of the solution of the induction problem to the theory of probability. The points which other theories do not maintain are the following ones:

a) Any special induction can be qualified by a degree of probability, so that a logic of probability takes the place of two-valued logic, for ordering scientific propositions.

b) Only the validity of the system of science as a whole cannot be qualified by a degree of probability. But the given system A of science of to-day can be qualified, if it is imbedded in a larger system B, by increasing experimental knowledge.

c) The principle of induction can be demonstrated as the only premise of the calculus of probability. From this it follows that with the justification of the principle of induction, all exigencies for a theory of future-propositions are fulfilled. Without such a demonstration, it might have been possible that science might contain still other principles, the validity of which would have to be shown.

For the foundation of these ideas I must refer to my book "Wahrscheinlichkeitslehre" (Leiden, Holland, A. W. Sijthoff's Uitgevers). The only point of correspondence which I find in Feigl's theory is the idea that induction is to be justified as the most favorable proceeding for obtaining future-propositions. But I would say that the realisation of this programme in the form of an exact demonstration can only be obtained after showing the logical function of the principle of induction in the theory of probability.

To summarize: I am very glad that H. Feigl is *now*, so near to my point of view. The change of view by the Vienna circle was very evident at the recent congress in Paris, where Carnap developed a theory of "confirmation" (Bewährung) instead of truth—whereas 6 years before, at the Congress of Prague, he put the question to me, in all seriousness, whether a man of science would be allowed to maintain a statement of which he was not absolutely sure. I answered then, that he has to do it, because he has no other ones—a point of view which Carnap is adopting but now. It is true, Carnap and his friends do not yet agree with me, that his "confirmation" is nothing but a high degree of probability, that his "resolution" to accept a proposition is allowed only if a high degree of probability for the proposition is shown,

or in another sense the proposition is shown to be the "most favorable stake" (as I call it), and that his scale of "Sicherheitsgrad" is to be replaced by my logic of probability. But I may hope that the Vienna circle will accept that some day, too; and to avoid the chance of their speaking of a new approximation of mine to their standpoint, I would be glad if you, dear Sir, would communicate my letter to your readers. For relativity is good in physics—but not here.

HANS REICHENBACH.

Istanbul-Kadiköy,
Mühürdar Caddesi.

REVIEWS AND NOTES

Einheit der Wissenschaft. Prager Vorkonferenz der Internationalen Kongresse fuer Einheit der Wissenschaft—1934. Felix Meiner, Leipzig. Pp. 204. RM 10.5.

The publication of this material in book form (it originally appeared in the fifth volume of the journal *Erkenntnis*) makes contact easy with the most vigorous and the most promising contemporary movement in the logic of science and scientific philosophy. This movement (variously described as logical positivism, rationalistic empiricism, scientism, scientific empiricism) draws together within itself the types of interest represented in the historical forms of empiricism, the more critical form of pragmatism, and the newer mathematical logic. It is therefore a logico-pragmatico-empiricism that has taken on a genuine international character. Similar tendencies, though without the wide unification now becoming apparent, had sprung up in a number of countries, with Mach, Peirce, Poincaré, and Russell playing decisive rôles. The main impetus to a wider form of organization was given especially by Carnap, Neurath, and Reichenbach. A congress at Erlangen in 1923 was followed by Congresses at Prague (1929) and Königsberg (1930). The international character of the interests represented was becoming more and more apparent, and at the Prague conference of 1934 (reported in this volume under Neurath's editorship) an organizing committee composed of Carnap, Frank, Jörgensen, Lukasiewicz, Morris, Neurath, Reichenbach, Rougier, and Schlick was constituted to lay plans for a series of International Congresses for the Unity of Science. The first of these congresses, was held in Paris September 1935.

The present volume is composed of papers read at the Prague Conference, supplemented by three papers (by Hosiasson, Nagel, Schlick) read at the Eighth International Congress of Philosophy, by reports of some of the discussions of the papers which took place, by biblio-biographical notes on those who participated in the congress, and by bibliographies of relevant American and Polish literature. Of the seventeen central papers, all but three are in German, and these three are accom-

panied by German summaries. The papers may be roughly divided into three groups: historical, polemical, "constructive."

The opening remarks of Philipp Frank gave something of the antecedents of the congress. A paper by Charles Morris (*Some Aspects of Recent American Scientific Philosophy*) was built around the thesis that what is distinctive in the philosophy of the United States has grown out of the fertilization of philosophy by the acceptance of the spirit and results of the scientific habit of mind. Jan Lukasiewicz, in *Aspects of the History of the Logic of Propositions*, traced in a masterful manner the development of his topic, revealing the importance of Stoic and late scholastic logic when seen from the perspective of symbolic logic. Jörgen Jörgensen discussed *Some Highpoints in the Development of Formal Logic Since Boole* (calling attention, incidentally to the derivation of truth-value tables from Boole and their use by Jevons, Venn, Peirce, and Schröder). The paper by Kasimir Ajdukiewicz on *Logical Anti-Irrationalism in Poland* is of especial interest in that it gives a general survey of the important developments in Poland, its utility to those not commanding Polish being enhanced by the addition of a comprehensive annotated bibliography.

The polemical papers illustrated little sympathy for the current forms of metaphysics frequently indulged in by scientists. An article by Moritz Schlick (*On the Concept of Wholeness*) maintained that descriptions in terms of whole or parts represent two possible types of linguistic apparatus and not two kinds of objective properties, so that current appeals to "wholeness" for the most part represent a confusion of factual and linguistic data. The study by Edgar Zilsel, *P. Jordan's Attempt to Save Vitalism by Quantum Mechanics*, presented a number of relevant considerations against the widespread tendency to use certain interpretations of recent physical data as supporting vitalistic and indeterministic theories in biology. Philipp Frank's discussion, *Does Modern Physics Support a Spiritualistic Interpretation?* took the form of maintaining against Jeans and Eddington that modern physics stands in no different relation to the concepts of "mind" and the "subjective" than did classical physics. Louis Rougier, in *Scholasticism and Logic*, presented the incompatibility of basic features of scholasticism with the most widely accepted positions of the new logic, thus amplifying from the side of logic the general attack on scholasticism, as internally inconsistent and inconsistent with Aristotle, contained in his extensive volume, *La Scolastique et le Thomisme.*

The remaining papers are positive attempts to solve specific problems.

Otto Neurath (*Unity of Science as a Task*) stressed the position that such unity does not entail the pseudorationalistic view of a single fixed and unalterable science, but is rather an opportunity, favored by the present cultural period of history, for coöperative work to unify science where possible and to extend scientific method to all possible domains. Charles Morris considered *The Relation of the Formal and Empirical Sciences within Scientific Empiricism*, attempting to show that logical analysis is a special type of empirical analysis (namely, the determination of what we are committed to within the domain of symbols if we follow certain rules for the use of symbols) and that the formal sciences as involving observations on symbols fall within a version of empiricism designated as "scientific empiricism." Rudolf Carnap's analysis of *Formal Science and Factual Science* was in a way complementary to the previously mentioned paper, stressing the position that the similarity of methods between the two types of science must not obscure the fact that the formal sciences consist of analytic propositions, while the propositions of the factual sciences are synthetic. The paper presented a classification of propositions and, incidentally, accepted the instrumentalistic interpretation of the rôle of the formal sciences within science as a whole. In his paper, *The Scientific World-Perspective*, Kasimir Ajdukiewicz maintained that the intermediation of a conceptual apparatus in all knowledge, resting upon the acceptance of rules of signification for the component symbols, involved the view that science is to the last degree conventional, and that along side of science there exist a number of other world-perspectives neither more nor less true. The significant contribution of Alfred Tarski (*Some Methodological Investigations Concerning the Definability of Concepts*) developed theorems to determine when one concept is definable in terms of a given set of concepts and when the concepts of a deductive system are "complete," thus carrying out for concepts inquiries usually restricted to propositions. Janina Hosiasson (*Probability and Inference from Partial Premises*) investigated, with rather unexpected results, the relation of a proposition to a part of the proposition from which, taken as a whole, it strictly follows. In *The Logic of Reduction in the Sciences*, Ernest Nagel made an excellent analysis of the various senses in which one science can be reduced to another, and his results should be carefully considered in relation to the general thesis of physicalism that all propositions can be "reduced" to propositions of physics.

The point of liveliest interest arose out of Hans Reichenbach's presentation of *The Logic of Probability*, in which he presented the thesis of his

since published book, *Wahrscheinlichkeitslehre*. His proposal involves a logic with a continuous scale of truth-values, and in terms of which the two and three valued logics appear as special cases. He held that this logic provided the proper basis for the theory of probability, that the logic of probability is the genuine logic of science, and that with the development of this logic the problem of induction is solved. All of these claims were vigorously challenged and as vigorously defended. The discussion has continued in *Erkenntnis*, volume 5, pages 228–294.

It is not impossible that the systematic development of the attitudes only sampled in this volume will prove to be the inauguration of a new era in the history of science and philosophy.

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La Logique et sa Caricature. By Marcel Boll. Paris. Les Éditions Rieder, 1935. Pp. 49.

The work "La Logique et sa caricature dans les questions actuelles" by Marcel Boll represents an effort to visualize in Psychology the results of the unification of the two forms of logic that characterize, on the one hand, scientific thinking, and, on the other, everyday, practical thinking. These two forms, termed "Objective Logic" and "Affective Logic" by Théodule Ribot, stand today at variance, their influence in the affairs of mankind being out of proportion to their individual merits.

M. Boll devotes himself in large part to the analysis and definition of the two forms of logic and to the denotation of the points of conflict between them in numerous examples culled from all fields of life. Objective Logic is essentially an "adaptation to facts" (Ribot), founded on experiment and independent of the preferences of the observer, and cognizant in non-Aristotelian fashion of third possibilities in so-called dilemmas. Its particular function is to rectify the pernicious errors of Affective Logic as applied habitually by the masses of people, intellectual and otherwise. "Imprisoned in the subjective" and adapted "to beliefs, to desires and aversions," this logic has been, and is yet, productive of enslavement to the codes of tradition, of nationalistic and racial frenzy, of economic injustice, of metaphysical nonsense, and of intellectual fallacies of all kinds committed unrestrainedly by rhetoricians and literati. Proceeding from the emotions, Affective Logic is the device of primitive or debilitated minds intent on ends and mendacious on means; confronted with the grossest contradictions, this logic remains unfractured and constitutes, indeed, a point of departure for hostility to science.

The case for the fusion of the two forms—really, the supersession of one—rests on the positive knowledge of the natural laws governing human conduct; that is, it is a problem of Applied Psychology. Here M. Boll invokes "the ineluctable dictatorship of preferences," "the static predominance of the affectivity," and a system of biological, psychic, and social values created by E. Goblot as basis for a program of studies of what is without doubt an extremely arduous problem. Thoroughly deterministic in outlook, he considers the approach as along scientific lines: the psychic dispositions are susceptible of physical treatment; the affectivity has no real (dynamic) existence, and, for the "psychic instruments," there are merely nerves and muscles. If the unification be eventually brought about, the author depicts an improved human, "an ideal man" in whom there "will dominate an excellent *activity* (generator of gayety, of movement, and of disinterestedness) and of solid *judgment*."

HARRY MALISOFF.

BOOKS RECEIVED

The Attitude of Voltaire to Magic and the Sciences, by Margaret S. Libby. Columbia University Press, 1935. $3.75.

A History of Science, Technology and Philosophy in the Sixteenth and Seventeenth Centuries, by A. Wolf. The Macmillan Co., 1935. $7.00.

A Source Book in Physics, by W. F. Magie. McGraw-Hill Book Co., 1935. $5.00.

Behavior, Knowledge, Fact, by A. F. Bentley. Principia Press, 1935. $3.50.

Locke and Scepticism, by Albert Hofstadter. Albee Press, New York, 1935.

Philosophy and the Concepts of Modern Science, by Oliver L. Reiser. The Macmillan Co., 1935. $3.50.

Possibility. University of California Press, 1934. $2.25.

Logik der Forschung, by Karl Popper. Julius Springer, 1935.